CORPS OF ENGINEERS
U. S. ARMY

COMPREHENSIVE REPORT
INVESTIGATION OF MILITARY CONSTRUCTION IN ARCTIC AND SUBARCTIC REGIONS
1945-1948

APPENDIX I
AIRFIELD SITE STUDIES AT NORTHWAY AIRFIELD, ALASKA

PREPARED BY
ST. PAUL DISTRICT
CORPS OF ENGINEERS
FOR
OFFICE OF THE CHIEF OF ENGINEERS
AIRFIELDS BRANCH
ENGINEERING DIVISION
MILITARY CONSTRUCTION

JUNE 1950

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APPENDIX I

AIRFIELD SITE STUDIES AT NORTHWAY AIRFIELD, ALASKA

I Introduction

1. **PURPOSE.** The object of this investigation is to collect basic physical data on soil characteristics, ground temperatures, groundwater, foundation designs, and other factors as they affect designs and construction at this site, with particular reference to permanently frozen ground and its associated problems. The purpose of this investigation is to observe the effect of permafrost on the facilities of the Northway Airfield throughout a series of seasonal cycles.

2. **PLAN OF INVESTIGATION.** In reviewing the information obtained from the following analysis, the fact that the structures had been heated well over a year before observations were started should be borne in mind. Structures and utilities, with the exception of the hangar and runway, were turned over to the War Assets Administration in the summer of 1948 for disposal. Future observations will be taken monthly at the hangar and runway until underground temperatures at the hangar have stabilized. The investigation, which was undertaken to determine the causes of construction difficulties and the means necessary to overcome these difficulties, has been conducted in the following manner:

a. Subsurface explorations. Numerous core and churn drilling operations from 30 to 50 ft in depth were conducted throughout the area to accurately determine the depths to permafrost and to obtain core samples for subsequent laboratory tests to determine the characteristics of the surface and subsurface soils. Many of these operations were conducted in specific locations to permit the subsequent installation of ground temperature measuring equipment. (See Plates I-1, I-5, I-6, I-7 and I-8.)

b. Groundwater wells. Churn drill holes were drilled at various locations to permit the installation of groundwater well pipes to determine seasonal water table fluctuations.

c. Probings. Probings supplemented by auger borings were taken at periodic intervals to determine the depths of seasonal frost and permafrost.

d. Vertical movement observations. Numerous vertical movement observation points were installed on the airfield facilities such as the runway, hangar and other buildings. Periodic observations were referred to a series of permanent bench marks.

Figure I-1. Northway Airfield, Alaska, June 1946

3. **LOCATION, TERRAIN AND DRAINAGE.** Northway Airfield is located at 62° 58' north latitude, 141° 58' west longitude in the flood plain of the Nabesna River and its tributary, Moose Creek. It is about 230 air miles southeast of Fairbanks, Alaska and 30 air miles west of the Canada-Alaska boundary. For a topographic map of the area see Plate I-1. The airfield was constructed on a relatively flat flood plain of the Nabesna River and its tributary, Moose Creek. A sand dune underlies the northeastern end, and the

southwestern end rests on an abandoned drainage channel once occupied by the Nabesna River. The balance of the field is located on an interchannel area of a flood plain which includes portions of several cave-in lakes. The vegetation consists of scattered groves of spruce, birch and aspen with numerous willow thickets. The ground is covered with a thick carpet of moss and peat. Below a 3- to 6-ft surface layer subject to seasonal thawing and freezing, the permafrost layer exists in varying thicknesses of from 90 to 150 ft. Figure I-1 shows in excellent detail the airfield and the surrounding terrain. Except for a few minor sections and for a short period of time during the summer months, no normal groundwater table exists at this site due to the proximity of the upper surface of the permafrost to the normal ground surface. Deep groundwater determined by well drilling operations was encountered below the permafrost layer at a depth of approximately 240 ft± below the surface, and is used for a potable water supply. The general trend of surface drainage is to the south toward Moose Creek. Runway drainage was provided by construction of parallel side ditches permitting surface and storm waters to drain into the Nabesna River and Moose Creek.

4. **WEATHER.** A First Order US Weather Bureau Station was established at the Northway Airfield in October 1942. Climatological observations have been made continuously since that time. The observations give the following information:

TABLE I-1

CLIMATOLOGICAL DATA

Calendar Year	Degree-Days Above 32°F	Degree-Days Below 32°F	Mean Annual Temp, °F	Precipitation in In. Total	Precipitation in In. Snow
1943	3,044	5,761	24.7	11.6	16.8
1944	2,966	5,403	24.8	15.5	37.4
1945	2,647	6,135	22.4	11.4	23.3
1946	3,200	6,564	22.7	12.3	25.3
1947	2,857	5,687	24.2	11.7	39.3
1948	2,863	6,884	20.8	10.1	57.2

The maximum recorded temperature during the period of observation was 88°F on 8 May 1947, and the minimum -70°F on 3 February 1947. For meteorological data at this airfield, see Plates I-2, I-3, and I-4.

5. **SOILS.** Beneath the moss- and peat-covered surface layer, exploratory boring holes to depths of 30 to 50 ft were made and, in many instances, used to permit the subsequent installation of ground temperature measuring equipment. A review of the subgrade soil texture indicates it to be predominantly fine, black sand, including variable layers of silt, coarse sand, gravel and ice lenses. See Plates I-5, I-6, I-7, and I-8 for exploratory borings at the airfield site.

6. **CONSTRUCTION HISTORY.** The original runway at the Northway Airfield was constructed under direction of the Civil Aeronautics Administration in 1941 and 1942 to provide access to the outpost defense fields by pursuit-type aircraft and to provide a link on the inland air route through Alaska to Asia. It consisted of a 5300- by 500-ft runway

constructed by stripping the moss and surface vegetation an average depth of 10 in. to frozen ground and backfilling with sand obtained from adjacent borrow pits to an average depth of about 2 ft. A sand-asphalt-emulsion pavement, 350 ft wide, 5 in. thick on the central 150 ft, and 4 in. thick on the shoulders, was placed over the length of the runway. Also, miscellaneous dwellings and operational buildings were constructed at that time. Later, at the request of the Army, the original runway was completely reconstructed and extended, in 1943 and 1944, to a 7500-ft length by constructing an 1100-ft extension to each end. This was effected by excavating to an average depth of 3.5 ft to permafrost, wasting the material and immediately backfilling with sand and/or fine gravel. In making the east runway extension, Moose Creek was deflected around the east end of the runway by a diversion channel. The sand removed in the excavation of the diversion channel was used in making the fill for the east runway extension. The parking apron was extended and two taxiways, 2500 by 75 ft and 2700 by 75 ft, were constructed. An asphalt-emulsion pavement, 7 in. thick, was placed over the runway and one 5 in. thick over the parking apron and taxiways. Construction of both the original and the extended and expanded runway was performed by the Morrison-Knutson Construction Company, under contract with and under the supervision of the Civil Aeronautics Administration. The hangar and all operational buildings, including powerhouse, motor vehicle and equipment repair depot, barracks, dispensary, etc., were constructed in the 1943-1944 seasons by the Metcalf, Hamilton, Kansas City Bridge Company, under contract with and under the supervision of the Northwest Service Command, Alaska District, Corps of Engineers. Subsequent to completion of construction of the extended runway, in the summer of 1944, seasonal frost action necessitated remedial surface reconstruction consisting of scarification and the placement and compaction of additional bituminous materials in August 1945 and August 1947.

7. **PERMANENT BENCH MARKS.** Vertical control for the airfield was established through a series of bench marks. The control bench mark, BM Pump House No. 1, is located on a well casing placed 240 ft in the ground which is not affected by frost action. Several bench marks were placed under different conditions and by di[illegible]t methods so that behavior of the various installations could be studied and criteria [illegible]eloped for the installation of permanent bench marks in permafrost. See Plate I-1 for bench mark locations. A review of periodic observations taken on these bench marks from June 1945 through April 1948 indicates that with the exception of BM "A" Pump House No. 2, located on a steel casing extending to a depth of 140 ft in the ground, the variation of which is negligible, variations in elevation from 0.026 ft to 0.073 ft are shown for bench marks which are set in permafrost to a depth from 15 to 40 ft below the ground surface. These minor variations undoubtedly are mainly due to the usual instrumental errors. Bench marks USC & GS Northway and Muller 8, 9 and 11, which were set in the active zone in varying depths from 2 to 7 ft, show unsatisfactory erratic changes and are used for observational purposes only. Stable vertical control points or bench marks may be obtained by placing a vertical pipe to a depth in the permafrost at least equal to twice the thickness of the frost zone of the ground; however, in placing the vertical control points, care must be taken to avoid areas where the permafrost may be affected by heated structures or utilities.

II Runway Tests

8. **DESCRIPTION.** Plate I-1 shows layout of runway base line stations, ground temperature observation holes, groundwater well installations, frost level observation holes, and bench mark locations.

a. Subsurface explorations. Plate I-5 shows exploratory borings along the edges of the runway; the borings show that the base materials below the bituminous runway surfacing consist mostly of sand and fine sands to a depth of approximately 5 ft which, in turn, are underlain to a depth of 25 ft below surface by natural soils comprised mainly of fine and medium black sands, gravel, with some pockets and intermittent strata of silt and sandy silt.

b. Material analysis and tests. Core samples at varying depths were taken in the majority of exploratory holes drilled adjacent to the runway. For dates of drilling operations and core sample numbers, see Plate I-5. Laboratory tests to determine physical constants, mechanical analysis, and grain-size accumulation curves were made for each sample. Table I-2 gives the laboratory analysis for soil samples numbers 29, 30 and 33, exploratory boring hole no. 6. Plate I-9 shows grain-size accumulation curves which

TABLE I-2

ANALYSES OF TYPICAL SOIL SAMPLES
NORTHWAY AIRFIELD RUNWAY STA 60+00
22 AND 23 APRIL 1945 -- SURFACE ELEV 1708.03 FT

Sample No.	29	30	33
Depth below ground surface, ft	1.5 to 3.5	16.4 to 18.5	26.3 to 30.5
Physical Constants			
1. All fractions of sample			
moisture, % of dry wt	31	23	26
Natural density, lb per cu ft	90	93	90
Specific gravity	2.71	2.71	2.72
Natural porosity, %	47	45	47
Natural voids ratio	.88	.82	.89
2. Fraction passing no. 40 sieve			
Plasticity index	Nonplastic	Nonplastic	Nonplastic
Mechanical Analysis			
Percent of total sample			
Grain size in in. or US standard sieve no.			
Gravel: no. 10 to 3 in.	0	4	0
Coarse, 1 to 3 in.	-	0	-
Medium, no. 4 to 1 in.	-	1	-
Fine, no. 10 to no. 4	-	3	-
Sand: no. 200 to no. 10	25	94.5	100
Coarse, no. 40 to no. 10	1	29	23
Fine, no. 200 to no. 40	24	65.5	77
Silt or Clay:			
Less than no. 200	75	1.5	0
Effective size in mm	.008	.18	.2
Uniformity coefficient	5.5	2.2	1.55
Class (textural)	Sandy silt	Sand	Sand
USED soil group	ML	SP	SP
Miscellaneous Characteristics			
Color	Gray	Black	Black
Frozen or unfrozen	Frozen	Frozen	Frozen
Ice lenses present	Few (thin)	None	None

represent typical laboratory analyses of all samples taken at the site. A review of these samples which were taken from an exploratory hole located in an undisturbed area adjacent to the north edge of the runway indicates the subsoil beneath a surface layer of moss, peat, and sandy silt, to be fine, medium and coarse-grained, nonplastic sands.

c. Ground temperature installations. Core drilling operations for the 16 ground temperature holes were started on 19 March 1945 and completed on 31 May 1945. See Plate I-5 for hole numbers, locations, dates of drilling, and soil sample numbers. The installation of ground temperature measuring equipment, consisting of mercury thermometer strings, was started on 5 May 1945 and was completed on 2 October 1945. During the period from 4 April through 6 April 1946, the mercury thermometer string installations in holes 1, 2, 4A, 5A, 7A, 9, 11A and 14B were replaced with thermocouple installations.

d. Ground- and surface water observation installations. The installation of groundwater well pipes in varying depths from 5 to 10 ft below surface, determined respectively by either the depth of the frost zone or the top elevation of the permafrost layer, was completed in August 1945 at locations shown on Plate I-1. Groundwater observation wells WA-1 to WA-16 are located adjacent to runway ground temperature installations T1 to ts-16. Other wells, WB-1 to 7 and WB-11, 12, 15 and 16, and WC-6, 7 and 15, are located at varying distances north and south of the runway wells. These installations consisted of 2-in.-diameter iron pipes in varying lengths, capped at each end and slotted at random intervals with 1/8- by 12-in. slots which in turn were covered with screen. To obtain information on surface water elevations, staff gages were installed in Moose Creek, at the east end of the runway, and in the Nabesna Slough, at the west end of the runway, on 5 May 1945, and daily readings were taken during the open water seasons. To supplement these readings, ten 2-in.-diameter slotted pipes were installed to specific elevations in the various lakes and marshes surrounding the airfield and weekly observations were taken. In August 1947, the previously installed staff gages and slotted pipes were removed and replaced with staff gages WG 1 through WG 10 at locations shown on Plate I-1. Daily observations were continued at gages WG 5 and WG 10 and at weekly intervals on the balance of the installation.

e. Vertical movement observations. Runway vertical movement observations are referred to a series of bench marks placed along the base line, namely, US Engineer BM's 1 through 5, which are periodically checked with the control bench mark, PBM Pump House No. 1. The main base line is situated 175 ft north of the center line of the runway. Vertical movement observations consisting of runway cross-section surveys are taken at 50-ft intervals along the runway. See Plate I-1 for locations of bench marks, base line and stationing.

f. Frost level observations. Probings through the bituminous surface at locations shown in Plate I-1 were taken at periodic intervals during the thawing seasons to determine the variations of the active zone.

g. Observations and measurements. Subsequent to installation of the mercury thermometer ground temperature units in the 16 runway temperature holes, observations were taken twice weekly until 5 April 1946, at which time mercury thermometer units in temperature holes 1, 2, 4A, 5A, 7A, 9, 11A and 14B were replaced with thermocouple units. Observations were continued on a daily basis for the thermocouple installations and on a twice weekly basis for the remaining mercury thermometer installations until 15 September 1946, after which the observations were reduced to a twice weekly basis until 30 June 1947. Observations have been taken weekly from 30 June 1947 to October 1948 and monthly since that time. Frost level probings to determine the depths of seasonal frost and the depths to permafrost were taken at monthly intervals for the period from 15 July 1945 to November 1945 and at 2-month intervals during the thawing seasons thereafter. The initial vertical movement survey on the runway, comprised of surface cross sections at 50-ft stations and 25-ft intervals on each station, was run on 16 April 1945, and successive observations were taken on 21 May 1945, 14 August 1945, 22 March 1946, 17 September 1946, and 11 April 1947.

h. Analysis of observations. A review of all runway ground temperature data for the period of observation, exclusive of temperature holes 8, 12 and 15, indicates that the average maximum yearly depths to permafrost occurring in the month of October were 9.0 ft in 1945, 10.5 ft in 1946, 9.7 ft in 1947, and 10.6 ft in 1948, and that seasonal frost and permafrost join either in late November or early December. Temperature holes 8, 12 and 15 were not used in the determination of the average seasonal maximum depth to permafrost under the runway, because the greater depths to permafrost in these locations were caused by prior natural conditions rather than by construction operations. A review of the borings, Plate I-5, shows the absence of permafrost to depths in excess of 30 ft in holes 12 and 15, and 26.6 ft in hole 8. Inspection of the site topography, Plate I-1, shows that the airfield is constructed on an area comprised largely of cave-in lakes, marshes, and abandoned stream channels. In arctic and subarctic locations of this nature, permafrost is generally encountered at greater depths under and immediately adjacent to streams, lakes and marshes. Hole 8 is located in the old Moose Creek stream bed. Moose Creek was diverted to its present location prior to construction of the easterly runway extension in 1943-44. Hole 12 is located adjacent to the northerly end of a marsh, and hole 15 adjacent to the northerly end of a cave-in lake. The average maximum depth of seasonal frost in these three holes was 7.1 ft in April 1946, 8.3 ft in April 1947, and 8.1 ft in April 1948. Plates I-10, I-11, I-12 and I-13 show ground isotherms for temperature hole 6 for the period from 25 May 1945 through 31 October 1948. Hole 6 is typical of the majority of runway ground temperature installations. Probings were taken at monthly intervals for the period from July through October 1945 at the probe hole locations shown on Plate I-1. With the exception of probe holes in the vicinity of temperature holes 8, 12 and 15 (described above), the average maximum depth to permafrost in October 1945 was 8.0 ft which compares favorably with the 9.0-ft depth indicated by the 0°C isotherms in the ground temperature installations. However, as the probe holes used for the observations were located approximately 30.0 ft north and/or south respectively from the adjacent ground temperature holes, it was believed that a more accurate comparison of depths to permafrost would be obtained if observations of this nature could be taken in the

immediate vicinity of the temperature holes. The probe holes were relocated to positions adjacent to the temperature holes in September 1946, and the observations gave the following information: Average maximum depth to frost in October 1946 from probings was 9.1 ft, from 0°C isotherms was 10.5 ft; in October 1947 from probings was 10.3 ft, from 0°C isotherms was 9.7 ft. No probings were taken in 1948 but the average maximum depth from 0°C isotherms was 10.6 ft in October 1948. A typical cross section of the runway, station 60+00, showing a comparison of the vertical movements of the bituminous runway surface and the maximum depths to the permafrost table, as indicated both by probings and depths to the 0°C isotherm, is shown on Plate I-14. A review of all the runway vertical movement observations taken at intervals for the period from 7 March 1945 through 8 April 1947 shows a general over-all surface settlement of only 0.04 ft. However, it should be noted th · the runway was resurfaced in August 1945 and August 1947. The ma .imum settlement, which was local in nature, occurred at cross-section station 20+00 and averaged approximately 0.50 ft; conversely the maximum rise, which was more general in nature, occurred at cross-section station 40+00 and averaged approximately 0.14 ft. Profiles of successive runway center line vertical movement observations are shown on Plate I-15. These profiles show that the runway has reached a stable condition.

III Building Tests

9. HANGAR. The hangar is of the "Birchwood Type", 162.63 by 208.6 ft, exclusive of hangar door pockets and aprons. Construction of this structure was started in the summer of 1943 and completed in the late spring of 1944. Approximately the eastern half of the hangar slab and structure is supported on a compacted granular fill placed in a sand and gravel borrow pit that had previously been excavated to depths from 5 to 7 ft below surface to supply materials for construction of the original runway in 1942. The western half of the slab and structure is supported on a compacted granular fill placed after removal of active zone materials consisting of surface moss and peat underlain by fine-grained silt and sands to variable depths from 3 ft to 5 ft. For a dimensioned layout of the hangar including locations of ground temperature observation holes, frost level observation points (probe holes), and vertical movement observation points in, or in the immediate vicinity of, this structure, see Plate I-16. Figure I-2 is a general view of the hangar.

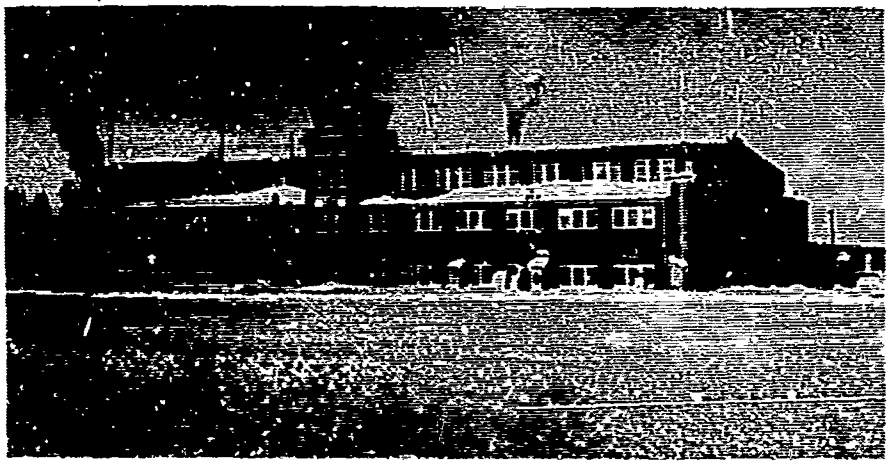


Figure I-2. Northway Airfield hangar, looking northwest. February 1947

a. Subsurface explorations. Plate I-6 shows exploratory borings in, or in the immediate vicinity of the hangar, which, in some instances, were subsequently used for the installation of ground temperature reading equipment. These explorations were commenced on 6 June 1945 and completed on 16 October 1945. The boring logs show that the hangar was constructed on base and subbase materials of approximately the following classifications to depths of 25 ft below surface: 0 to 5 ft, poorly graded sands with little or no fines (fill material); 5 to 15 ft, approximately 30% poorly graded gravel, 50% poorly graded sands, and in the vicinity of hole 39, some silt and peat; 15 to 25 ft, the material varies considerably from gravel to fine sand, silty sands and peat, with numerous ice lenses.

b. Material analysis and tests. Core samples at varying depths were taken in the majority of exploratory holes drilled in or in the immediate vicinity of the hangar. Laboratory tests to determine physical constants, mechanical analysis, and grain-size accumulation curves were made for each sample.

c. Installation of observational facilities.

(1) Ground temperature installations were made in temperature holes numbers 17A, 18, 19, 20A, 39, 40 and 42, during the period from 20 June 1945 to 1 November 1945. Subsequently, in the interests of more accurately determining the thawing effect of the heated hangar floor slab in the ground areas adjacent to the north and south hangar walls, supplementary thermocouple ground temperature installations TS-1 through TS-4, in the vicinity of temperature hole T-39, and TS-5 through TS-8, in the vicinity of temperature hole T-40, were installed in churn drilled holes during the month of July 1946. For locations and spacing of all hangar ground temperature installations, see Plate I-16.

(2) Frost level observation points (probe hole points) numbers 1 through 15, at various locations through the hangar floor slab and numbers 1-N, 2-N, and 3-N and 1-S, 2-S, and 3-S, located outside of and along the north and south hangar walls, respectively, were established in January 1945 by the Alaskan Department prior to receipt of authority from the Office, Chief of Engineers for pursuit of the current Permafrost Investigation by the St. Paul District. Additional probe hole point numbers 16 through 22 were added by this District in October 1945 to provide supplementary information inside and outside of the hangar. See Plate I-16 for locations.

(3) Vertical movement observation points were established in March 1945 on the north and south hangar wall concrete foundation piers and at intermediate points on the concrete hangar floor slab. In December 1945, 21 additional vertical settlement points 106 through 127 were established on the east-west concrete aprons and on concrete blocks placed parallel to and north and south of the respective north-south hangar walls. For locations of observation points, see Plate I-16.

d. Observations and measurements. Subsequent to installation of the respective observational units, ground temperature readings were taken at daily intervals until September 1946, then reduced to weekly readings until November 1948. Probings to determine depths to permafrost or depths of seasonal frost were initially taken at monthly intervals by the Alaskan

Department and such data furnished this office. These observations were continued at monthly intervals through March 1947 and subsequently at 2-month intervals. Vertical movement observations on all settlement points were made at approximately monthly intervals for the period from March 1945 through March 1947, after which time they were made at 2-month intervals.

e. Analysis of observations.

(1) Ground isotherm data. Temperature holes T-39, 40 and 42 were selected as typical to show the varying rates and depths of thaw. Hole T-39, located outside of and adjacent to the south hangar wall, shows a general lowering of the upper surface of the permafrost from an approximate depth of 19 ft in October 1945, caused by hangar heating operations during the 1944-45 winter season, to depths of approximately 27 ft in October 1946 and 28 ft in October 1947 and 1948. The upper soil stratum is subject to seasonal frost in varying depths from 5 to 8 ft. In hole T-40, located outside of and adjacent to the north hangar wall, no progression in the depth of thaw is indicated, and seasonal frost and permafrost join during the winter months. In hole T-42, located inside of and at the approximate center point of the hangar, initial observations on 1 November 1945 indicate the existence of permafrost in inclusive depths between 20 to 38 ft below the surface of the hangar floor slab. This initial 20-ft depth to permafrost is caused undoubtedly by hangar heating operations during the 1944-1945 winter season prior to the installation of observational equipment. Successive observations show a gradual reduction in thickness to depths between 23.5 to 32.0 ft in December 1946. As hangar heating operations in the 1946-47 winter season were not commenced until 26 January 1947, the progressive reduction in thickness of the permafrost ceased temporarily, and increased to depths from 23.2 to 44.0 ft in December 1947, and appears to be fairly stable in that position as the October 1948 observations show it to be present in depths between 26.0 and 44.0 ft. Plate I-17 shows comparative periodic 0°C isotherms on a staggered north-south hangar cross section, obtained by supplementing the original ground temperature installations T-40, 42 and 39 with the additional north and south thermocouple installations TS-5, 6, 7, and TS-1, 2, 3. The 0°C isotherm dated 10-15-45 is the initial observation made, and was taken prior to installation of the supplementary thermocouples. It shows that the upper surface of the permafrost ranges in depth in a north-south direction from 7.6 ft at T-40 to 18.0 ft at T-42 and 19.2 ft at T-39. It should be noted that these depths include the thawing actions of two previous seasons of structure heating. Successive observations as shown by 0°C isotherms show a gradual but diminishing rate in depth of thaw in holes T-42 and 39 which apparently has stabilized in hole 39 after March 1947. The combined effect of structure heating operations and the sun's rays on the southerly exposed portions of the structure are clearly evidenced by the existing thawed layer between the bottom of the seasonal frost and the upper surface of the permafrost at hole T-39. Conversely, the shading effect of the north wall permits confluence of the active zone and the permafrost in hole T-40. This condition is further borne out by a review of three years of temperature observations in holes ts-17-A, 18, 19 and 20-A, located outside and adjacent to the respective SW, SE, NE, and NW corners of the hangar. See

Plate I-16. These observations show that, with but minor seasonal variations, the dates and average maximum depths of thaw and average dates of confluence of the active zone and permafrost are as follows:

TABLE I-3

TEMPERATURE DEPTHS TO PERMAFROST -- HANGAR

Hole No.	Location	Average Depths and Dates Max Thaw	Confluence
ts-17-A	SW Corner	Oct 15 15.9 ft	Apr. 15
ts-18	SE Corner	Oct 15 15.8 ft	Apr. 1
ts-19	NE Corner	Oct 15 7.8 ft	Nov. 1
ts-20-A	NW Corner	Oct 15 11.6 ft	Dec. 1

As heating operations in the 1946-47 winter season were not started until 26 January 1947, a marked slowdown in the thawing rate was shown for a short period thereafter. All operational structures except the hangar were turned over to the War Assets Administration for disposal, consequently, structure heating operations were discontinued. However, monthly ground temperature observations under the hangar will be continued for informative purposes as a check on fluctuation of the underlying permafrost.

(2) Frost levels. Probings to permafrost by the Alaskan Department were made at monthly intervals for the period from 24 January 1945 to 27 August 1945 through hangar floor slab points 1 to 15, and at outside north-south points 1-N, 2-N, 3-N, 1-S, 2-S and 3-S for the period from 24 April 1945 to 27 August 1945. See Plate I-16. Under the hangar floor slab, these probings showed an average depth to permafrost of 13.4 ft, on 24 January 1945, increasing to an average depth of 15.6 ft on 27 August 1945, with a maximum lowering from 13.8 to 17.8 ft or 4.0 ft at point 14 in the vicinity of the boiler room, and a minimum lowering of 14.1 to 14.9 ft or 0.8 ft at point 7 near the SE corner of the floor slab. Probings at points 1-N, 2-N and 3-N, showed an average depth to permafrost of 6.4 ft on 24 April 1945, increasing to an average depth of 8.6 ft on 27 August 1945, with a maximum lowering of 3.9 to 9.2 ft or 5.3 ft at point 3-N (outside NW corner) and a minimum lowering of 11.2 to 12.5 ft or 1.3 ft at point 2-N (outside NE corner of boiler room). Probings at points 1-S, 2-S, and 3-S showed an average depth of 9.1 ft on 24 April 1945 increasing to an average depth of 16.0 ft on 27 August 1945, with a maximum lowering from 6.0 to 18.3 ft at point 3-S (outside SW corner) and a minimum lowering from 17.5 to 20.6 ft or 3.1 ft at point 2-S (outside south hangar wall center point). In October 1945, the Permafrost Division established additional probe points 16 through 22 to obtain more data on the irregularity

of the penetration of the thaw. Periodic observations at the 22 points were taken at approximately monthly intervals from 3 November 1945 to 9 October 1947 by using a 1/2-in.-round, 30-ft-long steel rod. A review of the probing data obtained, including that taken by the Alaskan Department, is shown in Table I-4. Depths are referenced to the top of the hangar concrete floor slab.

TABLE I-4

PROBING DEPTHS TO PERMAFROST -- HANGAR

Probing Dates	No. of Probe Points	Depth to Permafrost in Feet		
		Average	Minimum*	Maximum*
1-25-45**	15	13.4	9.6(6)	17.1(2)
1-10-46	18	17.0	12.0(6)	19.7(2)
1-14-47	18	19.0	13.8(6)	21.3(2) 21.3(15)
10-9-47	18	19.6	14.2(6)	22+ (14) 22+ (15) 22+ (11) 22+ (5)

* Probe point nos. shown in parenthesis
** Alaskan Department probings

The above tabulation shows a general slowdown in the rate of the thaw. The thawing effect of the boiler room is clearly shown on Plates I-18 and 19. It is highly probable that the thawed belt (layer) extending south from the boiler room across the hangar in depths in excess of 22 ft is an old abandoned stream channel. Probe points 20 and 22, at the edges of the east and west concrete aprons, respectively, show maximum 9-ft depths of seasonal thaw in late fall followed by freezing solidly to permafrost in the winter.

(3) Vertical movement observations. Plates I-18 and I-19 show periodic vertical movement profiles of the 14 north-south hangar reinforced concrete pier column footings and vertical movement profiles of the 12 reinforced concrete slab points located immediately adjacent to the respective north-south walls of the hangar. Plate I-18 shows an average maximum settlement of 0.143 ft for the 14 north wall footing piers, varying from 0.055 ft at pier 2-B to 0.37 ft at pier 9-B, in the immediate vicinity of the boiler room. The 14 south wall footing piers show an average maximum settlement of 0.596 ft, varying from 0.103 ft at pier 14-C to 0.99 ft at pier 7-C. Plate I-19 shows an average maximum settlement of 0.140 ft for the 12 slab points adjacent to the north wall, varying from a rise of 0.013 ft at point 1 to a settlement of 0.962 ft at point 29-A. The 12 slab points adjacent to the south wall show an average maximum settlement of 0.593 ft varying from 0.073 ft at point 7 to 1.011 ft at point 36-A, which is the maximum recorded settlement during the period of observations. Excluding the localized settled area in the vicinity of the boiler room, the gradual general trend of slab settlement is from the north

wall to the south wall, and also from the east and west edges toward a south-central irregularly-shaped area bounded by points 35-A, 31-A, 39-A, 47-A, 51-A and 50-A. In this specific area, the average maximum settlement was 0.832 ft varying from 0.689 ft at point 39-A to 1.011 ft at point 36-A. The slab settlement throughout the structure is so uniform that no difficulties in operation resulted. Minor cracks occurring in the slab can be considered as temperature cracks. Observation points on the east and west concrete aprons show only minor variations.

10. MOTOR POOL. The motor pool is a standard theater-of-operations type structure with over-all dimensions of 65.5 by 104.5 ft, exclusive of a 16.0- by 24.5-ft furnace room contiguous to its west wall. See Plate I-20 and Figure I-3. Construction commenced early in the fall of 1943 and was completed during the following winter. Prior to foundation construction, the general area topsoil consisting of moss, peat and fine-grained black sand was excavated to an average depth of 2 ft and backfilled with granular material. Deeper excavations were made for the column pier footings, the grease pit, and the furnace room.

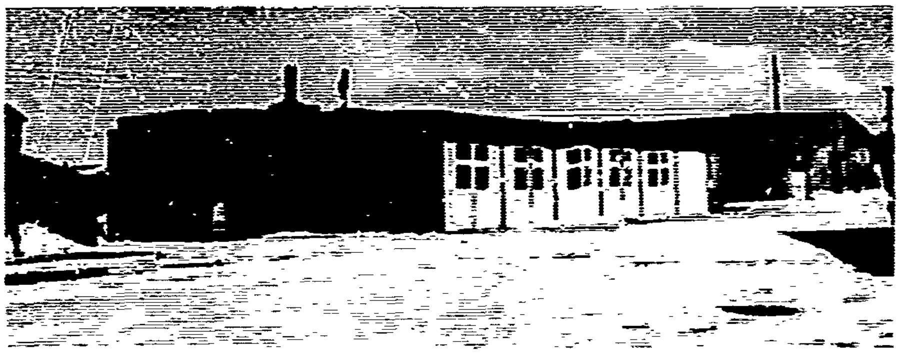


Figure I-3. Northway Airfield motor pool, looking northeast. May 1946

a. Subsurface explorations. Plate I-7 shows exploratory borings made in and adjacent to the motor pool. These holes were subsequently used for the installation of ground temperature reading equipment. A review of the boring logs indicates that the motor pool was constructed on base and subbase materials of approximately the following classifications to a depth of 25 ft below surface: 0 to 5 ft, poorly graded gravel and sand with some fines; 5 to 15 ft, mostly silt and peat with some traces of sand and gravel; 15 to 25 ft, mostly silt with some fine sands and clay. Numerous ice lenses are present at depths of 5 to 25 ft. Under natural conditions, permafrost is normally encountered at depths of 3 to 5 ft below surface in the vicinity of this structure.

b. Material analysis and tests. Core samples at varying depths were taken in all exploratory holes. Laboratory tests to determine physical constants, mechanical analysis, and grain-size accumulation curves were made for each sample.

c. Installation of observational facilities.

(1) Ground temperature installations (thermocouple T, mercury thermometer strings ts) were made in temperature holes T-23, T-24, ts-26, ts-27 and ts-28 during the period from 11 July to 7 August 1945. (See Plate I-20.)

(2) Frost level observation points (probe hole points) were established at the locations shown on Plate I-20 on 4 May 1945.

(3) Vertical movement observation points, consisting of spikes in the wood columns supported on concrete piers and pier footings and points on the furnace room concrete floor slab, were established at the locations shown on Plate I-20 on 10 October 1945.

d. Observations and measurements. Subsequent to the installation of the respective ground temperature reading units, readings were taken at daily intervals until September 1946 when they were reduced to semiweekly intervals. In April 1947 and thereafter, readings were taken at weekly intervals until the early fall of 1948 when the structure, which was sold by the War Assets Administration, was removed by the purchaser. Probings to determine the depths to permafrost or the depths of seasonal frost were taken at approximately monthly intervals during the period from May 1945 through March 1947 and at 2-month intervals until December 1947. Vertical movement observations on all points were made at approximately monthly intervals until June 1947, after which time they were taken at 2-month intervals until May 1948.

e. Analysis of observations.

(1) Ground temperature. Temperature holes T-23, T-24, ts-26 and ts-27, which are located at various distances from 6.4 to 9.9 ft outside the approximate center points of the respective north, south, west and east walls of the structure, show the average maximum depths to permafrost occurring in October 1945 to be 7.0 ft, in October 1946 to be 7.2 ft, in October 1947 for holes T-23, T-24 and ts-27 (ts-26 was discontinued on 31 March 1947) to be 7.1 ft. Due to dismantling operations only holes T-23 and T-24 could be observed in October 1948, and their average maximum depth was 7.6 ft; in all instances, seasonal frost and permafrost joined either in late October or early November. Temperature hole ts-28, located at the approximate center point of the building, shows a progressive rate in depth of thaw, by heating operations, from 8.4 ft in August 1945 to 12.4 ft in November 1946. As heating operations for this structure were discontinued after the 1945-1946 winter season, the seasonal frost and permafrost joined in October 1947. The maximum depth of seasonal thaw at this location in 1948 was 6.2 ft on 15 September. These observations show that, in fine-grained frozen subsoils under structures of this nature, the thawing action is confined mainly to the covered area and usually extends outward therefrom only about 3 or 4 ft.

(2) Frost levels. For probe points located outside the motor pool, the following tabulation of averaged depths for probings taken adjacent to the respective north and south walls shows the marked effect of the shading as against the sun's rays on soils adjacent to the south wall of the structure. For locations, see Plate I-20. At these locations, seasonal frost and permafrost normally join in late October along the north side and in late November along the south side. Probe points 2 through 7, located on the east, north-south section inside the structure, show average maximum probing depths to permafrost as follows: 8.3 ft on 5 November 1945; 9.9 ft on 25 November 1946; and 7.2 ft on 7 November

TABLE I-5

AVERAGE PROBING DEPTHS IN FEET TO PERMAFROST
MOTOR POOL

Dates of Observations	North Side Probe Points 8, 9, 11 and 12	South Side Probe Points 1, 10, 19 and 20
7-11-45	3.4 ft	5.3 ft
11- 5-45	5.5 ft	6.5 ft
7-19-46	5.1 ft	7.3 ft
10-15-46	6.4 ft	7.6 ft
5-15-47	1.6 ft	3.6 ft

1947. Probe points 13 through 18, located on the west, north-south section inside the structure, show average maximum probing depths to permafrost as follows: 8.2 ft on 5 November 1945; 10.9 ft on 25 November 1946; and 8.2 ft on 7 November 1947. The fact that motor pool heating operations were discontinued after the 1945-1946 winter season is clearly shown by the gradual raising of the permafrost, which is occurring with a noticeable edge effect from the north and south walls to the center.

(3) Vertical movement. Initial observations taken on 2 April 1945 show the average elevation of the three furnace room concrete floor slab points 1, 2, and 3 to be 1709.30 ft. This average elevation includes all previous settlement occasioned by the 1944-1945 winter season heating operations. Following observations taken on these three points show an average maximum settlement of 0.57 ft (elev 1708.73) on 14 October 1946. As structure heating operations were discontinued after the 1945-1946 winter season, a gradual rise in elevation of the furnace room floor slab occurred, with a final recorded elevation of 1708.91 ft on 6 November 1947 or a rise of 0.18 ft. On 2 April 1945 concrete slab vertical movement observation points were established at all of the structure concrete floor panel corners. Due to erratic movement in the floor panels, mudjacking operations were performed in May 1945 to obtain a more uniform floor surface. The effects of such actions were, however, only temporary. Early in October 1945, to facilitate observations, the concrete floor panel points were discontinued and replaced with spikes, points P-1 through P-40, driven in the timber columns supported on reinforced concrete pier footings. Observations taken on 10 October 1945 show the average elevation of the 40 points to be 1714.94 ft. Successive observations show a gradual lowering for a minimum average elevation of 1714.57 ft (-0.37 ft) on 14 October 1946. The area of maximum settlement was located in the vicinity of the south end of the grease pit near the furnace room. Point P-18, south end of grease pit, showed the maximum settlement of 0.92 ft on 14 October 1946. Point P-39, near the northeast corner of the structure, showed the minimum settlement of 0.02 ft on 14 October 1946. Subsequent observations of the 40 column points show a gradual rise in elevation to an average of 1714.72 ft on 1 May 1948, or 0.15 ft over the maximum average low of 1714.57 ft on 24 October 1946. The

laterai heat transfer oi the associated subsurface soils outside the limits of the structure is shown by the fact that the minimum settlement occurs at the observation points adjacent to the outside walls. In instances where buildings of these types must be constructed in permafrost areas underlain by fine-grained, frost-acting soils, to prohibit detrimental thaw, utilities such as steam and power should be obtained from separate plants specifically designed for such purposes.

11. POWERHOUSE. The powerhouse was a rigid frame structure placed on a reinforced concrete slab of over-all dimensions of 55.7 ft by 65.3 ft. See Plate I-21 and Figure I-4. At the start of construction operations late in the fall of 1943, it was considered advisable to take special precautions to insure a stable foundation for the two large 350 kva diesel generators. To accomplish this, the area selected for the powerhouse was temporarily inclosed in a framed canvas structure and the ground steamed and excavated to a variable depth from 5 ft to 7 ft below the normal ground surface to insure the removal of all moss, peat, and fine-grained frost-susceptible materials. The area underneath the two proposed generator foundations was steamed and excavated an additional 2 ft, then backfilled with approximately a 2-ft layer of coarse-grained, black sand, compacted, and a supplementary 9-in. reinforced concrete slab placed thereon. After curing the slab, granular fill material was placed and compacted to grade in the entire area to permit construction of the regular reinforced concrete generator foundations and powerhouse concrete floor slab thereon. A heavy layer of bituminous expansion material was placed vertically around the generator bases to eliminate adhesion of the concrete floor slab. The standard underground exhaust pipes were converted to overhead exhausts to prevent the transmission of heat into the permafrost. Construction was completed early in the spring of 1944.

Figure I-4. Northway Airfield powerhouse, looking northwest (previous to fire on 25 December 1946). May 1946

a. Subsurface explorations. Plate I-8 shows exploratory borings, outside of but in the vicinity of the powerhouse, which were subsequently used for the installation of ground temperature measurement equipment. Making exception for the excavation and backfill performed under the structure proper, a review of the boring logs will show base and subbase materials of approximately the following classifications to a depth of 25 ft below surface: 0 to 5.0 ft, poorly graded sands with little or no fines; 5 to 15 ft, poorly graded gravels and sands with traces of silt; 15 to 25 ft, poorly graded sand, fine sands, sandy silt, and peat with ice lenses. In this area, under natural conditions, permafrost is normally encountered in varying depths from 3 to 5 ft below the surface.

b. Material analysis and tests. Core samples at varying depths were taken in

both observation holes. Laboratory tests to determine physical constants, mechanical analysis and grain-size accumulation curves were made for each sample.

c. Installation of observational facilities.

(1) Ground temperature installations were made in temperature holes numbers T-21 and T-22 in early July 1945. For locations, see Plate I-21. It should be noted that temperature hole T-22, on the north side of the powerhouse, was installed in the near vicinity of an existing underground utilidor which is heated during freezing periods and undoubtedly disturbs the permafrost and the ground temperature contours of the surface and subsurface materials in that area.

(2) Frost level observation points (probe hole points) were established at the locations shown on Plate I-21 on 24 January 1945.

(3) Vertical movement observation points were installed on the respective reinforced concrete pier footings around the outside wall of the structure and on the respective corners of the diesel generator foundations as indicated on Plate I-21 on 3 April 1945.

d. Observations and measurements. Subsequent to the installation of the respective ground temperature reading equipment, observations were taken at daily intervals until September 1946 when they were reduced to semi-weekly intervals; after April 1947 they were changed to weekly intervals. Although this structure was destroyed by fire on 25 December 1946, the ground temperature installations were not damaged and readings were continued. Probings to determine the depth to permafrost and/or the depths of seasonal frost were taken by the Alaskan Department at semimonthly intervals at frost observation points numbers 1 through 9 for the period from 24 January 1945 to 27 August 1945, and subsequently at the above nine points and additional points 10 through 15 at monthly intervals by employees of the St. Paul District Office, Permafrost Division, until destruction of the structure. Vertical movement observations at all points were taken at approximately semimonthly intervals for the period from 3 April 1945 to 29 October 1945 and at monthly intervals thereafter, until destruction of the structure.

e. Analysis of observations.

(1) Ground temperature. A review of the ground temperature data for holes T-21 and 22 for the period of observation is as follows: Hole T-21, located 9.7 ft south of the approximate center point of the south wall, shows a gradual lowering of the permafrost (0° C isotherm) from a depth below surface of 6.8 ft on 1 July 1945 to 18.0 ft on 25 December 1946. After the fire, the permafrost started gradually rising to the point where permafrost and seasonal frost joined on 15 March 1947. The actual maximum depths of seasonal frost at this location were 6.4 ft in March 1946 and 7.2 ft in March 1947, at which time seasonal frost and permafrost joined. In 1948, the seasonal thaw had reached to a maximum depth of 14.0 ft on 30 August, but was rapidly rising on 13 October when the installation was removed. Hole T-22, located 6.4 ft north of the approximate center point of the north wall and in the immediate vicinity of an underground utilidor

which is heated during freezing temperatures, shows a lowering of the permafrost from 13.2 ft on 12 July 1945 to 21.3 ft on 25 December 1946. However, the seasonal frost and permafrost in no instance join at this installation as is the case at T-21. The recorded depths of seasonal frost in no instance exceed 4.0 ft, undoubtedly as a result of heat transmitted by the utilidor. This installation was removed on 13 October 1948.

(2) Frost levels. Probe hole points 10, 11, 12, and 13, located at distances of 5.0 or 7.0 ft outside the approximate center points of the respective north, east, south, and west walls of the structure, show varying seasonal depths to permafrost as follows: Point 10, 7.0 ft north of the north wall near a heated underground utilidor, 13.7 ft on 6 November 1945, and 18.4 ft on 23 November 1946; point 11, 5.0 ft west of the west wall, 7.8 ft on 6 November 1945, and 9.2 ft on 23 November 1946; point 12, 7.0 ft south of south wall, 9.9 ft on 6 November 1945 and 11.3 ft on 13 November 1946; point 13, 5.0 ft west of the west wall, 9.1 ft on 6 November 1945, and 11.3 ft on 26 November 1946. Seasonal frost and permafrost joined at points 11 and 12 in February 1946. The average increase in depths to permafrost at points 1 through 9, 14A and 15, through the concrete floor slab inside the structure ranged from 12.7 ft on 6 November 1945 to 17.4 ft on 23 November 1946. Of these observations, the maximum lowering 9.2 ft occurred at point 14A in the vicinity of the heated utilidor.

(3) Vertical movement. For the period of observation from 3 April 1945 to 15 November 1946, the 9 observation points on pier footings showed an average maximum settlement of 0.082 ft, with a minimum settlement of 0.033 ft at point 15 and a maximum settlement of 0.190 ft at point 12. For the same period of observation, the 4 observation points on the north generator base showed that the average maximum settlement was 0.11 ft with a minimum of 0.053 ft at the SW corner, and a maximum of 0.184 ft at the NE corner; whereas, the average maximum settlement of the 4 observation points on the south generator base was 0.078 ft, with a minimum of 0.056 ft at the SW corner, and a maximum of 0.104 ft at the SE corner. Up to the time of its destruction by fire, the powerhouse required no unusual maintenance for either the structure or generators, and could be considered stable.

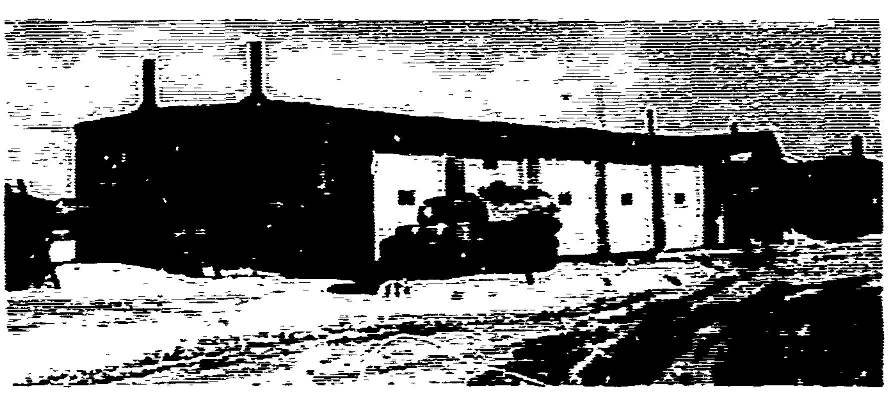


Figure I-5. Northway Airfield garage, looking northeast. May 1946

12. GARAGE. The garage is a standard theater-of-operations type structure with over-all dimensions of 32.4 by 100.3 ft. See Plate I-22 and Figure I-5. Construction commenced in the fall of 1943 and was completed in the spring of 1944. The structure proper is supported on reinforced concrete piers resting on reinforced concrete pier

footings. Prior to foundation construction, the general area topsoil consisting of moss, peat and fine-grained sand, was excavated to an average depth of approximately 2 ft and back-filled with granular material. Deeper excavations were necessary at the column pier footings, the grease pit, drain pit, and furnace room.

a. Subsurface explorations. Plate I-8 shows exploratory boring hole 29, located 7.0 ft west of the west wall of the garage furnace room, which was subsequently used for the installation of a mercury thermometer string ground temperature observation assembly. A review of the boring log will show that the garage was constructed on base and subbase materials of the following classifications to a depth of 25 ft below surface: 0 to 5 ft, poorly graded sands and sandy silts; 5 to 15 ft, inorganic silts, fine sands, traces of peat and some ice lenses; 15 to 25 ft, mostly sandy silts and peat with numerous ice lenses. This is poor subbase material for construction. Under natural conditions, permafrost is normally encountered at depths of 3 to 5 ft below the surface in this area.

b. Material analysis and tests. Core samples at varying depths were taken in this observation hole. Laboratory tests to determine physical constants, mechanical analysis, and grain-size accumulation curves were made for each sample.

c. Installation of observational facilities.

(1) Ground temperature installations were begun with core drilling operations for temperature hole ts-29, which were commenced on 11 August 1945 and completed on 17 August 1945. A mercury thermometer string assembly ground temperature installation was made on 26 August 1945. For location, type and spacing, see Plate I-22.

(2) Frost level observation points (probe holes) were established at the locations shown on Plate I-22 on 25 July 1945.

(3) Vertical movement observation points were initially installed on 8 April 1945 at the center points and along the respective edges and corners of the reinforced concrete floor slab panels. Due to irregular settlements encountered in the respective panels, the observation points, with the exception of the four corners of the furnace foundation, were relocated on 13 October 1945 as shown on Plate I-22.

d. Observations and measurements. Subsequent to installation on 17 August 1945, ground temperature observations were taken at semiweekly intervals until 11 March 1947, at which time they were reduced to weekly intervals until 28 October 1948. Probings to determine the depth to permafrost or seasonal frost were taken at approximately monthly intervals for the period from 27 July 1945 to 17 March 1947 and at 2-month intervals thereafter until 29 October 1947. Vertical movement observations were taken at approximately monthly intervals for the period from 8 April 1947, and at 2-month intervals thereafter until 16 August 1948.

e. Analysis of observations.

(1) Ground temperature. The initial observations at temperature hole ts-29 on 26 August 1945 show a depth to permafrost (0°C isotherm) of 9.0 ft.

This depth was undoubtedly caused by the proximity of the installation to the furnace room which was heated the previous 1944-1945 winter season. Subsequent observations show a steady progressive lowering of the permafrost to depths of 12.4 ft in October 1946, 13.2 ft in October 1947, and 15.8 ft in October 1948. The structure was heated in the 1946-47 and 1947-48 winter seasons. Seasonal frost at this installation varied from maximum depths of 4.4 ft on 1 May 1946 to 4.8 ft on 5 April 1947, and 4.8 ft on 7 April 1948. At no time during the period of observation did the seasonal frost and permafrost join.

(2) Frost levels. Probe hole points 1, 2, 9 and 10 show the following maximum seasonal depths to permafrost: Point 1, 7.0 ft south of the south wall, 6.2 ft on 5 November 1945, 7.5 ft on 21 October 1946, and 6.5 ft on 28 October 1947; point 2, 2.0 ft south of the south wall, 7.6 ft on 5 November 1945, 9.3 ft on 21 October 1946, and 8.6 ft on 28 October 1947; seasonal frost at point 1 varied from 3.2 ft to 4.3 ft and at point 2 from 2.7 to 3.6 ft. In no instances during the period of record did the seasonal frost and permafrost join at these points. The combined thawing effect of a heated structure and the sun's rays on soils adjacent to south walls is clearly shown; point 9, 2.0 ft north of the north wall, 5.8 ft on 5 November 1945, 7.9 ft on 21 October 1946, and 7.7 ft on 28 October 1947; point 10, 7.0 ft north of the north wall, 5.0 ft on 5 November 1945, 6.5 ft on 21 October 1946, and 6.9 ft on 28 October 1947. At these points, due to the shading effect of the north wall, seasonal frost and permafrost join in either late January or early February. Probe hole points 3 through 8, located inside the structure on a north-south section, show average gradual lowering depths to permafrost as follows: 8.0 ft on 25 July 1945, 9.1 ft on 13 December 1945; 12.3 ft on 27 December 1946; and 12.8 ft on 28 October 1947 (final observation). The plane of thaw beneath the structure is fairly uniform with only a minor (1 to 2 ft) depression in the central portion.

(3) Vertical movement. The initial set of vertical movement observations on the reinforced concrete floor slab panel points, excluding the furnace room, was taken on 8 April 1945. This set of observations showed an average floor slab elevation of 1711.67 ft, with a maximum elevation of 1711.91 ft at P7 and a minimum elevation 1711.43 ft at P12, for a surface variation of 0.48 ft. This irregular settlement was caused by thawing and compaction of the underlying subsoils as a result of heating operations in the 1944-45 winter season. In early May 1945, the concrete floor slab panels were mudjacked in an attempt to correct the uneven settlement, and the grease room floor rebuilt. Vertical movement observations taken after these operations on 16 May 1945 showed an average elevation of 1711.81 ft or a general over-all rise of (1711.81 - 1711.67 ft) 0.14 ft. The beneficial results of these mudjacking operations were shortlived as the final observations taken on the panel points on 25 September 1945 showed an average elevation of 1711.57 ft or 0.24 ft lower than the mudjacked elevation and 0.10 ft lower than the initial observation. Subsequent periodic vertical movement observations were taken on the 21 column spike points and point P16, which for ease of observation replaced the concrete floor slab panel points. See Plate I-22. The initial observation on these 22 relocated points showed an average elevation of

1713.23 ft. Successive observations through 16 August 1948 show a gradual continuous settlement to an average of 1712.52 ft or 0.71 ft. This settlement added to the 0.10 ft settlement prior to mudjacking operations gives an over-all average maximum settlement of 0.81 ft for points P1 through P22, excluding P16 on the concrete footing. P16 showed a maximum settlement of 0.69 ft. The average maximum settlement, 1.52 ft, occurred at points P12 and 13 and the average minimum settlement, 0.35 ft at points P21 and 22, at the northeast corner of the structure. Vertical movement observations on the four corners of the furnace room boiler foundation, points P2, 4, 5 and 6, for the period from 8 April 1945 through 16 August 1948 show an average gradual settlement from elevation 1711.72 ft to 1710.77 ft (0.95 ft). The settlement variation of the four points was negligible, less than 0.10 ft.

13. **FIRE STATION.** The fire station is an L-shaped, standard, theater-of-operations type structure. Its foundation is supported on timber piling placed butt down well into the permafrost in such a manner as to provide approximately a 2-1/2-ft air space between the bottom of both the wood and concrete floors and the normal ground surface. No skirting of the air space beneath the building was made except along the north wall where a fill was placed to serve as an approach ramp. Construction operations commenced in the summer and were completed in the late fall of 1944. The operational section of the structure is constructed on a reinforced concrete floor slab, while the crew quarters section is on an insulated wooden floor. See Plate I-23 and Figure I-6.

Figure I-6. Northway Airfield fire station, looking northwest. Crews' quarters in foreground, hose tower in center, fire station proper in right background. February 1947

a. Subsurface explorations. Plate I-8 shows boring hole 41, located 6 ft outside and east of the northerly section of the east wall of the fire station, which was subsequently used for the installation of a mercury thermometer ground temperature reading assembly. A review of the boring log will show that the fire station was constructed on materials of the following classifications to a depth of 25 ft below surface: 0 to 5 ft, poorly graded sand and silt; 5 to 15 ft, poorly graded sands and gravels; 15 to 25 ft, fine gray sands, silty sands, and some ice lenses. This material is suitable for timber piling foundation construction if an air space is used.

b. Material analysis and tests. Only visual classifications were made in this observation hole.

c. Installation of observational facilities.

(1) Ground temperature installation. Drilling operations for temperature hole ts-41 were commenced on 2 October 1945 and completed on 4 October 1945. A mercury thermometer ground temperature assembly was installed on 10 October 1945. For location, see Plate I-23.

(2) Frost level observation points. No frost level observation points (probe holes) were established at this structure because of the piling foundation and accompanying air space beneath the floor slab.

(3) Vertical movement observation points. Initially, on 25 June 1945, the following observation points were installed: 42 points at regular intervals on top of the concrete floor slab; 12 points consisting of spikes driven in the wooden columns in the operational portion of the structure; and 8 points at regular intervals on top of the wooden floor of the crew quarters. After a short period of observation, the necessity for this quantity of points was questioned and the number reduced to the following: 13 points at regular intervals on top of the concrete floor slab and 4 points on top of the wooden floor of the crew quarters. See Plate I-23 for location of revised vertical movement observation points.

d. Observations and measurements. Ground temperature observations in hole ts-41 were taken at semiweekly intervals from 10 October 1945 to 10 March 1947 and at weekly intervals thereafter until 27 October 1948. No probings to determine depths to permafrost or seasonal frost were taken. Vertical movement observations were taken at approximately monthly intervals for the period from 25 June 1945 to 3 March 1947 and at bimonthly intervals thereafter until 16 August 1948.

e. Analysis of observations.

(1) Ground temperature. The maximum depths to permafrost 6 ft north of the structure, as indicated by the 0°C isotherms, were: 10.7 ft in November 1945; 9.6 ft in November 1946; 8.0 ft in October 1947; and 8.6 ft in October 1948. In all instances, at this location, seasonal frost and permafrost joined in either late November or early December. The 2-1/2-ft air space prevents the transmission of heat from the structure into the underlying ground.

(2) Vertical movement. The average variation of the 62 originally installed observation points (described above) for the period of observation from 27 June 1945 to 12 September 1945 was +0.001 ft. The re-established 17 points (above described) show an average variation for the period from 12 September 1945 to 16 August 1948 of 0.081 ft. This structure is stable.

14. BOILER HOUSE. The boiler house, which was constructed to furnish steam for the overground and underground airfield utilidor system, and for heating the overground 100,000-gal., wooden water storage tank, is a 20-ft-4-in. by 32-ft-4-in. rectangular

frame structure constructed on a reinforced concrete floor slab, which in turn is supported on timber piling placed well into the permafrost in such a manner as to provide approximately a 2-1/2-ft air space between the bottom of the floor slab and the normal ground surface. Construction was accomplished in the spring of 1944. See Plate I-24 and Figure I-7.

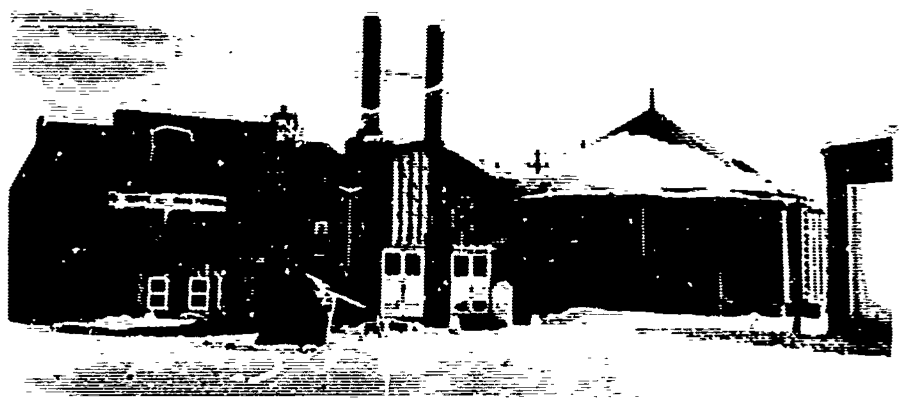


Figure I-7. Northway Airfield boiler house, looking southeast. Boiler house in center foreground. 100,000-gal. water storage tank right rear, powerhouse left rear. May 1946

a. Subsurface explorations. No specific observation boring was made in the immediate vicinity of this structure. However, hole 22 (see Plate I-8) located at the north side of the powerhouse and near the boiler house, shows a classification of base and subbase materials to a depth of 25 ft below surface as follows: 0 to 1.0 ft, moss and peat; 1 to 5 ft, poorly graded sands with little or no fines; 5 to 15 ft, poorly graded gravels and sand with traces of silt; 15 to 25 ft, poorly graded sand, fine sands, sandy silt, and peat with ice lenses. Under natural conditions, permafrost is normally encountered in varying depths from 3 to 5 ft below surface.

b. Material analysis and tests. No samples were taken in the immediate vicinity of this structure.

c. Installation of observational facilities.

(1) Ground temperature installation. No ground temperature reading installation was made in the immediate vicinity of this structure. For nearest installation, see hole T-22 shown on Plate I-21 and located approximately 80 ft east of the northeast corner of this structure.

(2) Frost level observation points. One probe hole point was established at the approximate center point of this structure on 4 April 1945 as shown on Plate I-24.

(3) Vertical movement observation points. Initially, on 4 April 1945, 15 vertical movement points were established on the surface of the concrete floor slab at the following locations: At the 4 corners of the structure and at various points immediately adjacent to the corners of the concrete boiler foundations and the gasoline motor-driven pump foundation. On 14 November 1945, the number of observation points was reduced to 9 and relocated as follows: c1 through c5 at regular intervals along the east-west center line of the concrete floor slab; c6 through c9 at regular intervals along the north-south center line. See Plate I-24 for revised locations.

d. Observations and measurements. Probings to determine the depth to permafrost under the approximate center point of this structure were taken at approximately monthly intervals for the period from 14 November 1945 through 17 March 1947 and at bimonthly intervals thereafter until 28 October 1947. Vertical movement observations were taken approximately at semimonthly intervals for the period from 4 April 1945 through 26 September 1945, at which time the points were relocated and observations continued at monthly intervals until 4 March 1947 and at bimonthly intervals thereafter until 16 August 1948.

e. Analysis of observations.

(1) Frost levels. The initial probings taken on 14 November 1945 indicated the permafrost to be at a depth 16.1 ft below ground surface. This depth is occasioned undoubtedly by the fact that this structure was heated for approximately an 18-month period prior to the initial observation. Continued observations show minor variations in the upper surface of the permafrost layer as follows: 16.4 ft on 23 November 1946 and 17.0 ft on 28 October 1947. The increased depth is negligible.

(2) Vertical movement. For the period from 4 April 1945 through 26 September 1945, the 15 points showed an average rise of 0.015 ft varying from 0.028 ft at point 7 to 0.10 ft at point 6. For the period from 12 October 1945 through 16 August 1948, the average maximum variation of the 9 c-points was 0.02 ft. This structure is stable.

15. **PUMP HOUSE NO. 2.** Pump house no. 2, which was constructed primarily to supply water to the dispensary and the adjacent troop barracks, is a 16-ft-4-in. by 18-ft-4-in. rectangular frame structure supported approximately one foot above normal ground surface on 8-in. reinforced concrete walls which extend through the active zone into the permafrost. Subsequent to the well drilling operations, and prior to foundation construction, the surface materials in the area, consisting of moss, peat and fine-grained soils, were excavated to an approximate depth of 2-1/2 ft and replaced with granular materials compacted in place to serve as a base for the 4-in. reinforced concrete floor slab. Prior to construction of the floor slab, additional excavations into the permafrost were made to permit constructing the reinforced concrete walls, the reinforced concrete saddle supports for the pressure water tank and the concrete pump base around the well pipe. Construction operations were accomplished in the summer of 1944. See Plate 1-24 and Figures I-8 and I-9.

Figure I-8. Northway Airfield pump house no. 2, looking northwest -- Liver Lake in background. May 1946

a. Subsurface explorations. Plate I-8 shows exploratory boring 25 located 7 ft 9 in. west of the center point of the west wall of the pump house, which was subsequently used for the installation of a mercury thermometer ground temperature reading assembly. A review of the boring log indicates base and subbase materials of approximately the following classifications to a depth of 25 ft below surface: 0 to 5 ft, poorly graded sands, silty and sand-clay mixture; 5 to 15 ft, sandy clays, silty clays, peat and some ice lenses; 15 to 25 ft, sandy silt, peat and ice lenses. Permafrost is normally encountered in depths from 3 to 5 ft below surface in the vicinity of this structure.

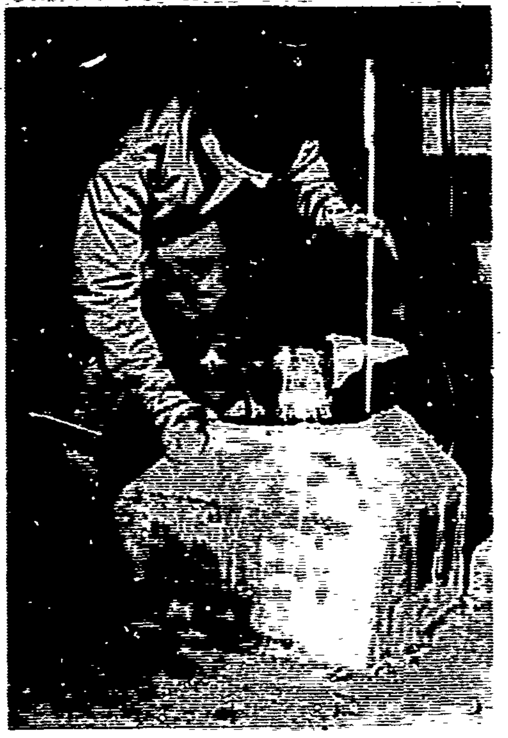


Figure I-9. Northway Airfield pump house no. 2, interior view showing settlement of pump footing. April 1946

b. Materials analysis and tests. Core samples at varying depths were taken. Laboratory tests to determine physical constants, mechanical analysis and grain-size accumulation curves were made for each sample.

c. Installation of observational facilities.

(1) Ground temperature installation. Core drilling operations for temperature hole ts-25 were commenced on 14 July 1945 and completed on 18 July 1945. A mercury thermometer ground temperature assembly was installed on 23 August 1945 as shown on Plate I-24.

(2) Frost level observation points. Probe holes were established on 16 November 1945 at the locations shown on Plate I-24.

(3) Vertical movement observation points. Foundation wall points and floor slab points were established on 4 April 1945 at the locations shown on Plate I-24.

d. Observations and measurements. Subsequent to the installation of ground temperature equipment on 23 July 1945, daily observations were taken until 2 October 1945, semiweekly until 19 March 1947, then weekly until 24 August 1948 when the installation was demolished. Probings to determine the depth to permafrost or seasonal frost were taken at approximately monthly intervals for the period from 16 November 1945 through 14 May 1947 and bimonthly thereafter until 25 October 1947. Vertical movement observations were taken semimonthly for the period from 4 April 1945 through 6 February 1946, at monthly intervals until 6 February 1947, and

bimonthly thereafter until 5 May 1948.

e. Analysis of observations.

(1) Ground temperature. For the period of observation, the maximum depths to permafrost occurring in the month of October, as indicated by the 0°C isotherm, were: 7.2 ft in 1945, 6.8 ft in 1946, 6.4 ft in 1947, and 6.0 ft on 24 August 1948. The gradual rise in the permafrost is undoubtedly a result of the fact that the well was not used and the structure not heated after the removal of troops in the summer of 1945. In all instances, seasonal frost and permafrost join in the month of November.

(2) Frost levels. Probings show a gradual lowering of the permafrost from 8.5 ft in November 1945 to 10.2 ft in October 1946, and a slow but gradual rise thereafter.

(3) Vertical movement. For the period of observation from 4 April 1945 to 5 May 1948, the following settlements were shown: Foundation corner points 1-F, 7-F, 13-F, and 10-F show an average elevation of 1711.31 ft on 4 April 1945, gradually lowering to an elevation of 1710.98 ft (-0.33 ft) on 5 May 1948, with a maximum settlement of 0.60 ft at point 7-F (NE corner) and a minimum of 0.17 ft at point 10-F (SW corner); the nine floor slab points show an average elevation of 1711.24 ft on 4 April 1945, fluctuating from 1710.95 ft (-0.29 ft) on 5 April 1946, to 1711.0 ft (-0.24 ft) on 4 June 1947 and 1710.98 ft (-0.26 ft) on 5 May 1948; the maximum settlement of 0.60 ft occurred at point 7-A (NE corner) in the vicinity of the pump footing and the minimum settlement of 0.14 ft at point 10-A (SW corner). In general, the trend of structure settlement is towards the northeast corner.

16. PUMP HOUSE NO. 1. Pump house no. 1, located approximately 70 ft north of the northwest corner of the hangar, serves as the source of water supply for the main operational buildings of the airfield, the utilidor system, and the 100,000-gal. water tank used for the fire-fighting supply. See Plate I-1 and Figure I-10. Well drilling operations at this location were started late in the fall of 1943, conducted through the 1943-44 winter season, and completed early in the spring of 1944. Due to the extremely low winter temperatures (-30° to -40° F), the drill rig and its appurtenant operating equipment were inclosed in a heated temporary structure to facilitate operations. Drilling operations were performed by continual steam jetting inside of and in advance of driving the 6-in. steel well casing. Thawed soils (fine black sands) were encountered below the permafrost which extended to

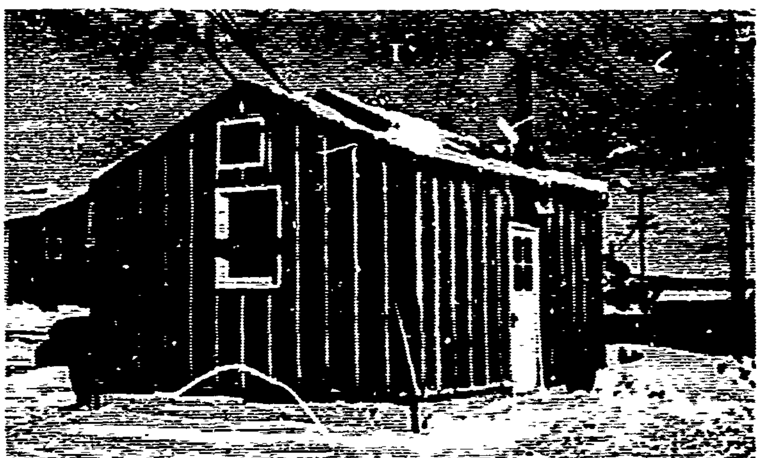


Figure I-10. Northway Airfield pump house no. 1, looking northeast. February 1947

a depth of approximately 150 ft below the surface. A suitable water-bearing gravel stratum was obtained at a depth of 242 ft. Upon completion of drilling operations the pump house was constructed. As a result of the continuous heating operations in the temporary structure enclosing the drill rig, the underlying surface and subsurface materials were thawed to a depth in excess of 6.0 ft. These thawed fine-grained materials were removed and replaced with granular materials, which were compacted to serve as a base for the pump house structure, the pressure water tank and the pump foundation proper. The structure is of the same type as pump house no. 2, see Plate I-24. As this structure is stable and in good condition, no observations were taken in or around it. A combination of the effect of the steam drilling and the temporary structure heat had undoubtedly compacted the underlying subsoils sufficiently to provide suitable bearing capacity, and subsequent frost action was prevented by the thawing action of continuous pumping operations. See Figure I-11 for an inside view of the pump house.

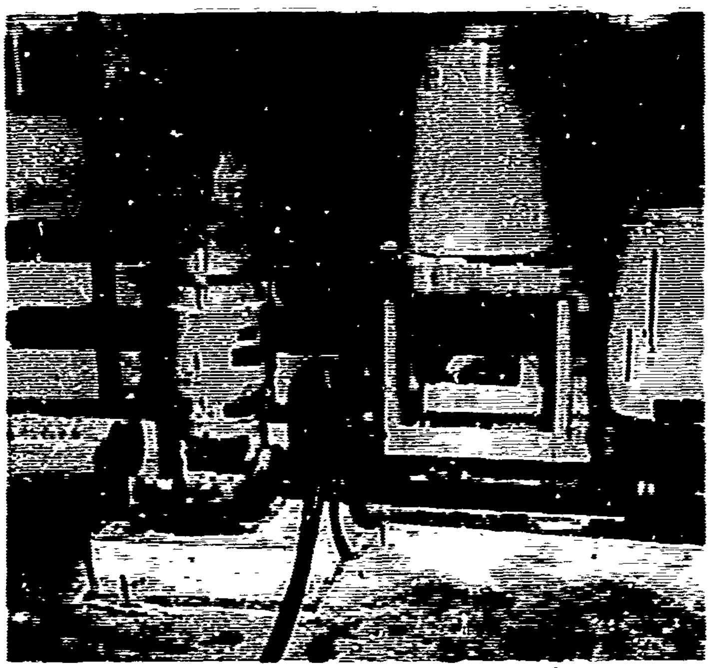


Figure I-11. Northway Airfield pump house no. 1, interior view showing stability of pump foundation. December 1947

17. ONE-HUNDRED-THOUSAND-GALLON WATER TANK. The water tank was constructed mainly to serve as a source of supply for fire protection. It is a 40-ft-outside-diameter, 11-ft high, circular, wood stave structure (see Plate I-1). For protection against freezing, the wood stave tank was inclosed in an octagonal shaped wood frame structure insulated with blanket type sheathing and surfaced with heavy bituminous-treated building paper fastened with vertical batten strips. The tank assembly complete with chime beams, floor and ceiling joists and decks and wall staves, was furnished to the site by the manufacturer, match-marked for proper erection. Construction started in the early spring of 1944 and was completed during the summer of that year. The base for the octagonal structure and tank consists of a reinforced concrete slab supported on asphalt-coated piling, placed at 5-ft intervals to such depths in augered holes as to insure a 4-ft encasement in permafrost. Subsequent construction operations provided approximately a 2-ft air space between the bottom of the tank and the surface of the concrete slab. See Figure I-7, page 23. This structure is stable and has presented no operational difficulties; consequently, no regular program of observations was considered necessary. On 2 December 1946, arrangements were made for the comparison of daily air temperatures taken under the approximate center of the tank and air temperature at a point 4 ft above the nearby bituminous-surfaced runway. The results of these comparative observations for the period from 2 December 1946 through 28 August 1948 (when dismantling operations on the tank began) show that the effect of the heated, insulated tank is to moderate, or raise the temperature under it an average from 3° to 4°C in the winter, and to reduce the summer temperatures by shading from 5° to 6°C. A marked reduction in the range of high and low peak temperatures is shown.

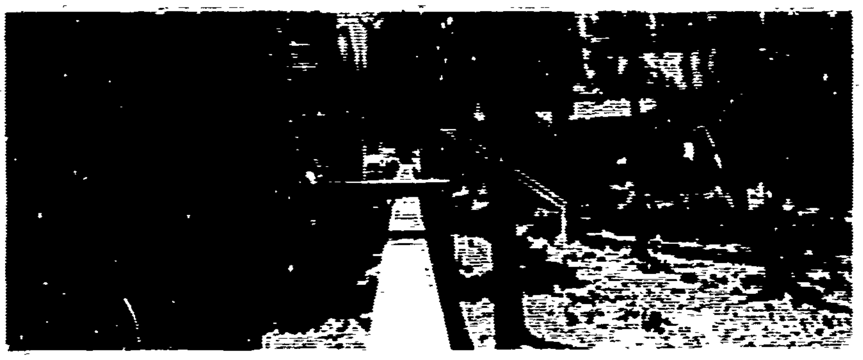
18. **UTILIDOR SYSTEM.** The utilidor system at the Northway Airfield supplies the operational and housing facilities at the site with water, steam and sanitary sewer services. The main artery of the system loops through the area and extends southwesterly through a treatment plant, and eventually discharges into Nabesna Slough. See Plate I-1. The main utilidor line of the system to the sewage treatment plant incloses a 6-in. C.I. sewer pipe, a 2-in. potable water line, and a 3-in. insulated steam line. The utilidor is an insulated rectangular plank box, 30-1/2 in. high by 34 in. wide, covered on the outside with 20-lb bituminous-treated roofing felt. The utilities are so supported within the box that air spaces are provided both between the pipes and the sides of the box. Construction commenced early in the spring of 1944 and was completed late in the summer of that year. In order to insure a gravity flow system for the main utilidor and from the structures being served, it was necessary to bury the utilidor below the normal ground surface, to support it on built-up crossbeams resting on the surface, or to support it on driven posts extending above the ground surface. See Figures I-12, I-13, I-14 and I-15. The water supply, under 60-psi pressure, is furnished for this system by pump house no. 1, while steam for heating both the utilidor system and the various structures which it serves is supplied by the boiler pump house. Considerable maintenance has been required in portions of the utilidor due to irregular settlement in the overground sections caused by insufficient penetration of support posts into permafrost, or inadequate trenching and improper backfilling with fine-grained, frost-active soils in the buried or partially buried sections. The fire-fighting system was constructed as an independent service. It consisted of a looped insulated 6-in. steel main originating and ending at the boiler pump house. It so traversed the airfield that hose valve connections were located in the vicinities of all operational structures, barracks, etc. In general, with the exception of road crossings, the fire main was supported approximately 2 ft above ground surface on treated posts installed well into the permafrost in augered holes. At road crossings it was enclosed in timber culverts. This was a normally dry system; water was supplied only when required, and then the system was completely drained. In future airfield construction, for economy and ease of operation, it is recommended that mains for fire-fighting purposes be enclosed in the main utilidor. The utilidor and fire-fighting systems were sold by the War Assets Administration and dismantled in August 1946.

19. EXPERIMENTAL AREA. The 500-ft-square experimental area, located approximately 3400 ft south of the center-line point of runway station 80+00, was selected and subdivided into 250-ft-square subareas for the purpose of obtaining observational data under the following conditions: area 1 (SW corner) cleared of trees and brush with surface moss and peat remaining; area 2 (NW corner) cleared of trees and brush and stripped of surface vegetation; area 3 (SE corner) left in natural state. For location with respect to the Northway Airfield, see Plate I-1. Locations of borings and test installations are shown in Plate I-25.

a. Subsurface explorations. Exploratory borings were taken at regular intervals around the perimeter and at the center point of the 500-ft-square area. These explorations were commenced on 17 August 1945 and were completed on 28 August 1945. In general, they show materials of approximately the following classifications to depths of 25 ft below surface: 0 to 1.5 ft, varying thicknesses of moss, peat and silty loam; 1.5 to 5 ft, fine sands and silty sands; 5 to 15 ft, poorly graded and fine sands; 15 to 25 ft, fine gray sand. During the period of explorations, the upper layer of the permafrost was encountered at variable depths from 2 to 5 ft below the surface.

b. Material analysis and tests. Core samples of varying depths were taken

Figure I-12. Utilidor in housing area rests on crossbeams placed on ground



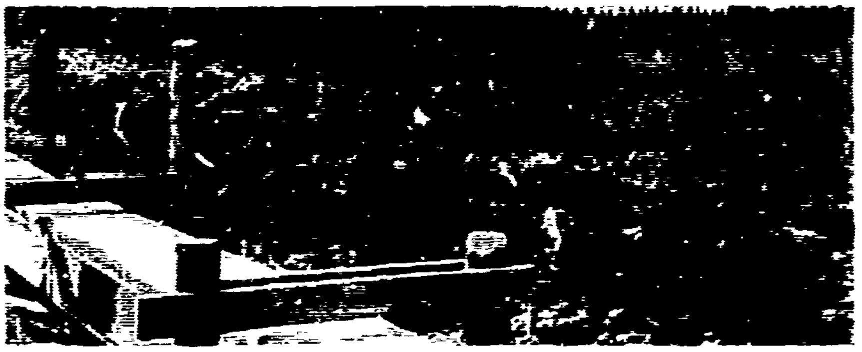


Figure I-13. Utilidor in partially excavated trench, resting on crossbeams and held in place by posts and crossties

Figure I-14. Utilidor for outfall sewer line, placed on posts with crossbeams and on crossbeams on the ground surface. Noticeable settlement may be attributed to improper construction by not placing the posts to adequate depths in permafrost

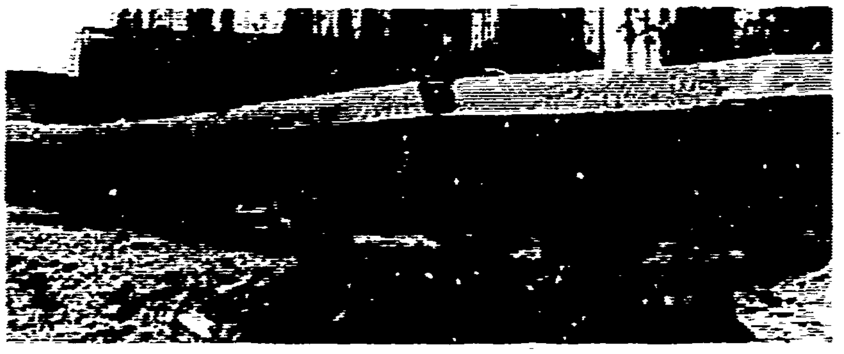


Figure I-15. Utilidor crossing flooded swampy ground and muskeg supported on driven posts and crossbeams. This section contains the outfall sewer to Nabesna Slough

Figures I-12, -13, -14,and -15 are typical of the utilidor installations at the Northway Airfield. In all instances, with the exception of Figures I-14 and I-15, the utilidors consist of an insulated plank box containing an insulated high pressure steam line, a return steam line, a water line and a sewage line. In Figures I-14 and I-15 the box contains only the steam line and an outfall sewer line. All photos taken August 1945

in all observation holes drilled in the experimental area. Laboratory tests to determine physical constants, mechanical analysis and grain-size accumulation curves were made for each sample.

c. Installation of observational facilities.

(1) Nine ground temperature installations, three at equidistant points in each subarea consisting of thermometer strings with 11 slow reacting mercury thermometers spaced at various depths, were assembled and installed in churn drilled temperature holes during the period from 28 September 1945 through 1 October 1945.

(2) Frost level observation points (probe hole points) were established at regular intervals, 16 in each subarea for a total of 48, on 1 September 1945.

(3) Vertical movement observation points, consisting of twelve truncated pyramid-shaped concrete monuments with embedded bolts for observation points, were installed, 4 in each area, on 23 October 1945. The monuments were placed in the respective areas so that the top surfaces were approximately level with the surrounding ground surface. Periodic observations on these monuments were referenced to a stable bench mark in the vicinity.

d. Observations and measurements. Ground temperature readings were taken at semiweekly intervals until 3 April 1947 at which time they were reduced to weekly intervals until 27 October 1948, at which time they were discontinued. Probings to determine the depth to permafrost were taken at monthly intervals for the period from 1 September 1945 through 21 November 1945 and semiannually thereafter until 2 November 1947. Vertical movement observations on the 12 concrete monuments were taken at approximately monthly intervals for the period from 23 October 1945 through 1 March 1947, and at 2-month intervals thereafter until 17 August 1948.

e. Analysis of observations.

(1) Ground temperature. The average maximum yearly depths to permafrost ($0^{\circ}C$ isotherm), for the three ground temperature installations in each subarea, are shown on Table I-6. As the subareas were not cleared until the fall of 1945, it is not believed the ultimate thawing effect occurred that year and, for the purpose of analysis, those depths should be disregarded. Seasonal frost and permafrost join in area 1 in early November, in area 2 in either late October or early November, and in area 3 in late September. This clearly shows the insulating effect of trees, brush and natural vegetation.

(2) Frost levels. The following tabulation shows a correlation of average depths to permafrost obtained by probing and by ground temperatures. The variance between 0° C isotherm depths and probing depths is difficult to explain; however, the trend in the three sections is similar. It is difficult to accurately describe the upper limit of permafrost by the use of only probings. However, they are of considerable value in preliminary field reconnaissance work.

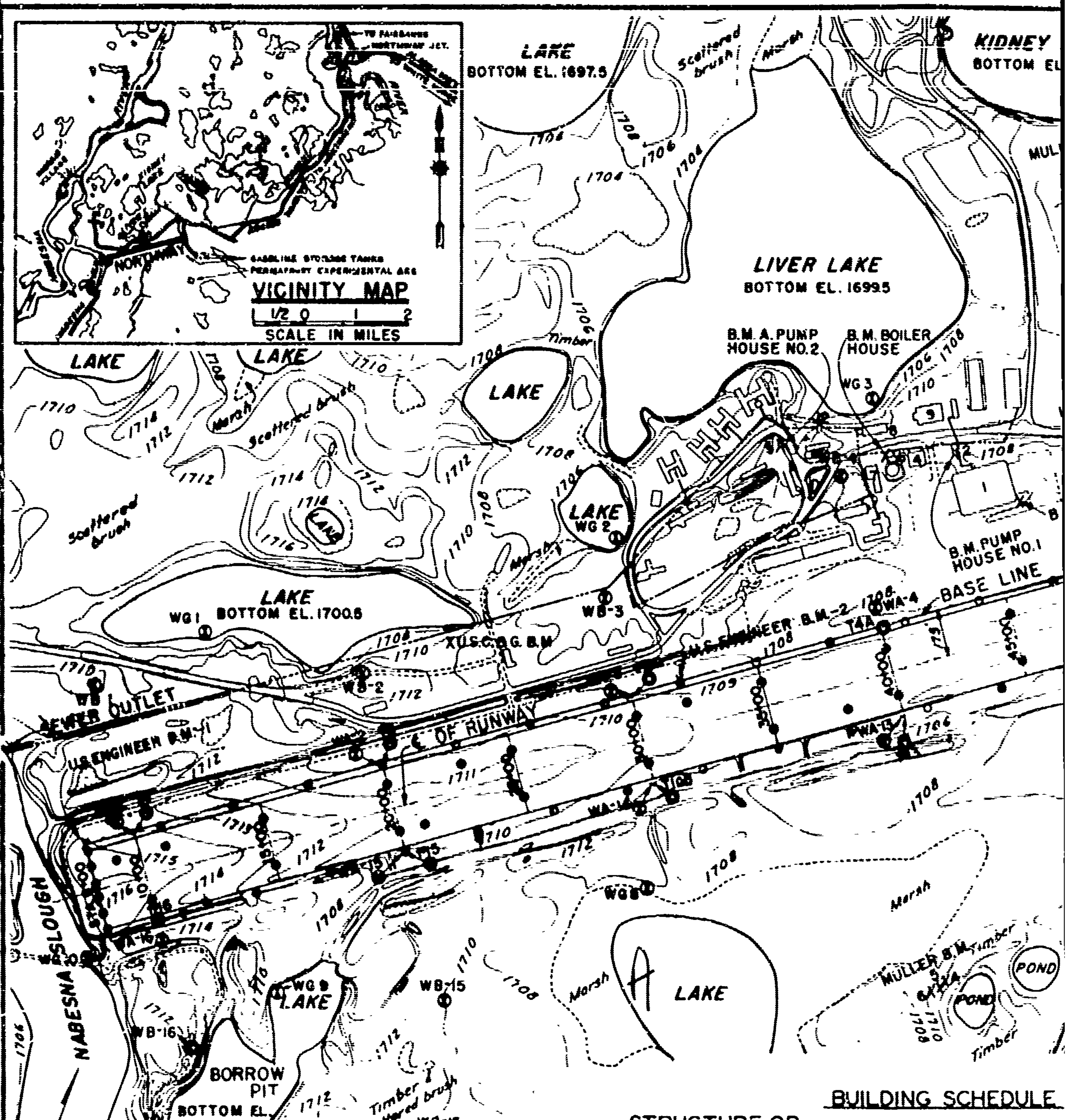
TABLE I-6

AVERAGE MAXIMUM DEPTHS TO PERMAFROST IN FEET
EXPERIMENTAL AREA

	Location, Type and Depth in Ft					
	Subarea 1 (Cleared trees & brush)		Subarea 2 (Stripped)		Subarea 3 (Natural surface)	
Dates	0° C	Probings	0° C	Probings	0° C	Probings
Oct. '45	6.7 ft	5.5 ft	5.9 ft	3.8 ft	-	-
Sept. '45	-	-	-	-	4.3 ft	2.3 ft
Oct. '46	8.3 ft	6.3 ft	7.0 ft	6.2 ft	-	-
Sept. '46	-	-	-	-	3.8 ft	2.7 ft
Oct. '47	8.8 ft	5.9 ft	8.1 ft	6.8 ft		-
Sept. '47	-	-	-	-	4.9 ft	3.6 ft
Oct. '48	8.2 ft	*	7.5 ft	*	-	-
Sept. '48	-	-	-	-	5.0 ft	*

* No observation.

(3) Vertical movement. Periodic observations taken on the 12 monuments from 23 October 1945 through 17 August 1948 show variations in the respective areas as follows: area 1, average maximum variation of the 4 points of 0.123 ft with the maximum variation point NW 4 being 0.197 ft and the minimum variation point NW 3 being 0.074 ft; area 2, average maximum variation 0.341 ft with the maximum of 0.429 ft at point SW 4 and the minimum of 0.195 ft at point SW 3; area 3, the average maximum variation of 0.830 ft with the maximum of 1.573 ft at point SE 3 and the minimum of 0.366 ft at point SE 2. In all three areas, the maximum rise in elevation due to seasonal frost occurs in either late March or early April, whereas the maximum settlement occurs in late October or early November. The average maximum seasonal depths to permafrost (0°C isotherms) for the period of observation are as follows; area 1, cleared of trees and brush, surface moss and peat remaining 8.0 ft; area 2, stripped of trees, brush, surface moss and peat, 7.1 ft; area 3, in natural state, 4.5 ft. Normally, it would be assumed that the depth of thaw would be greater in area 2 which was cleared of trees, brush and surface vegetation; however, the fact that the average surface elevation of area 1 is approximately 5 ft higher than area 2 and 10 ft higher than area 3 should be taken into consideration from the standpoint of the effect of the moderating influence of the groundwater table. In vertical movement observations, the frost action effect of the undisturbed surface, as compared successively to the surface covered with moss and peat and the stripped surface, is clearly shown.

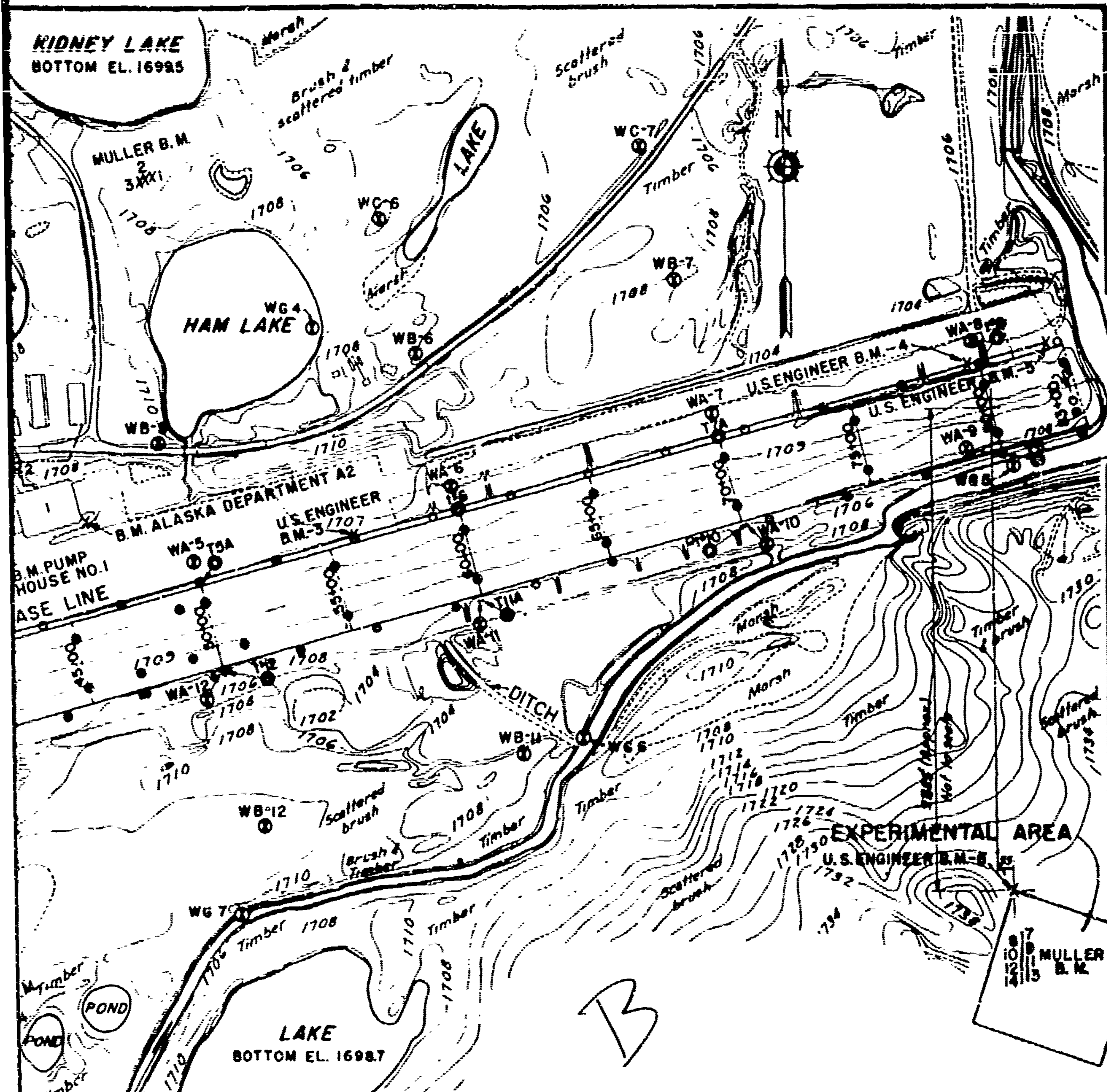


BUILDING SCHEDULE

STRUCTURE OR BUILDING NO.	SIZE	TYPE	PRESE
1	162.6'X 209.3'	FRAME	HANGER
2	16' X 18'	FRAME	PUMP H
3	16' X 18'	FRAME	PUMP H
4	55' X 65'	FRAME	POWER
6	20' X 32'	FRAME	BOILER
7	40' X 104'	FRAME	FIRE ST
8	324' X 100.3'	FRAME	GARAGE
9	64' X 104'	FRAME	ARMY M
12	18' X 29'	LOG-HOUSE	N.C.O. C

REFERENCES:
FOR LOCATIONS OF OBSERVATION HOLES AND POINTS IN AND IN THE VICINITY OF BUILDINGS AND THE EXPERIMENTAL AREA. SEE FOLLOWING PLATES.

OBSERVATION POINTS IN EXPERIMENTAL AREA__________PLATE I-25
OBSERVATION POINTS IN FIRE STATION ____________ " I-23
OBSERVATION POINTS IN BOILER HOUSE AND PUMP HOUSE_ " I-24
OBSERVATION POINTS IN POWER HOUSE_____________ " I-21
OBSERVATION POINTS IN MOTOR POOL BLDG._________ " I-20
OBSERVATION POINTS IN HANGER_________________ " I-16
OBSERVATION POINTS IN AND ADJACENT TO GARAGE_____ " I-22



LEGEND

——— UTILIDOR LINE (WATER-STEAM-SEWER)
X BENCH MARKS
o RUNWAY LIGHTS
STAFF GAGES
● FROST LEVEL OBSERVATION HOLES
◎ GROUND TEMPERATURE OBSERVATION HOLES
T THERMOCOUPLE UNITS
t° THERMOMETER STRINGS
⊗ GROUND WATER OBSERVATION HOLES

CHEDULE

PE PRESENT OFFICIAL USE
ME HANGER
ME PUMP HOUSE & WELL NO I
ME PUMP HOUSE & WELL NO 2
ME POWER PLANT
ME BOILER HOUSE
ME FIRE STATION
ME GARAGE
ME ARMY MOTOR POOL
OUSE N.C.O. CLUB

PERMAFROST INVESTIGATION
NORTHWAY AIRFIELD, ALASKA
RUNWAY & VICINITY
GENERAL PLAN

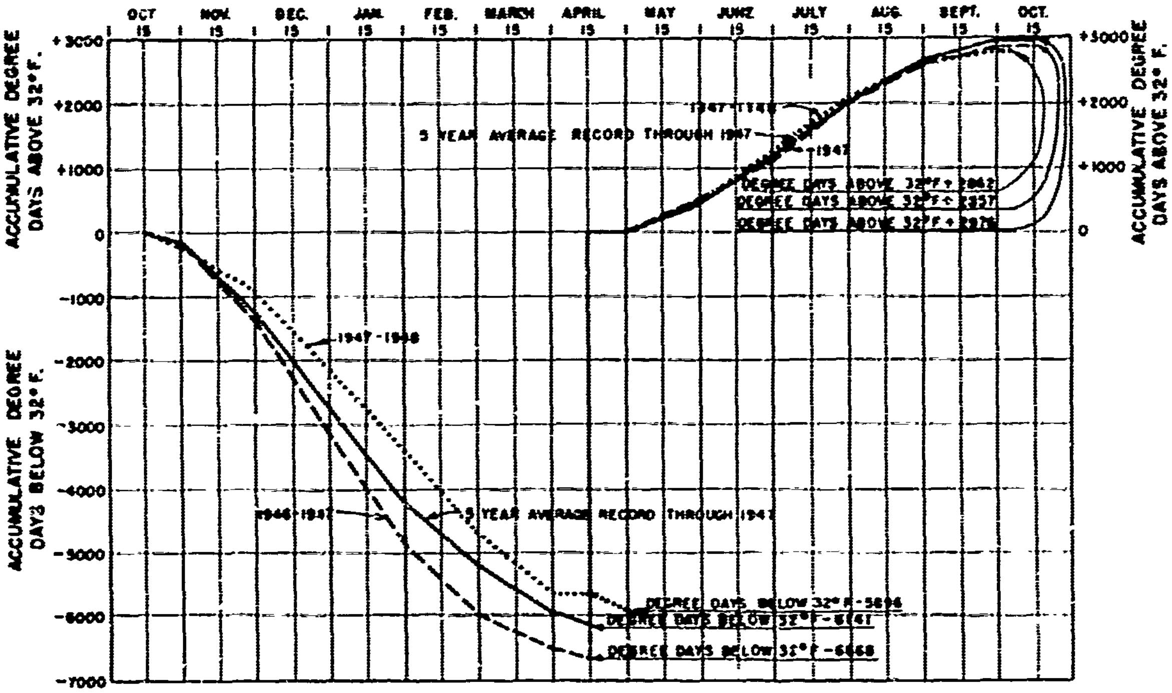
500' 250' 0 500'
SCALE IN FEET

IN I SHEET — SHEET NO. I

U.S. ENGINEER OFFICE, ST. PAUL, MINN. MAY 1950

DRAWN BY. O.P.A.
TRACED BY. O.P.A.
CHECKED BY. V.O.N.

PLATE I - I

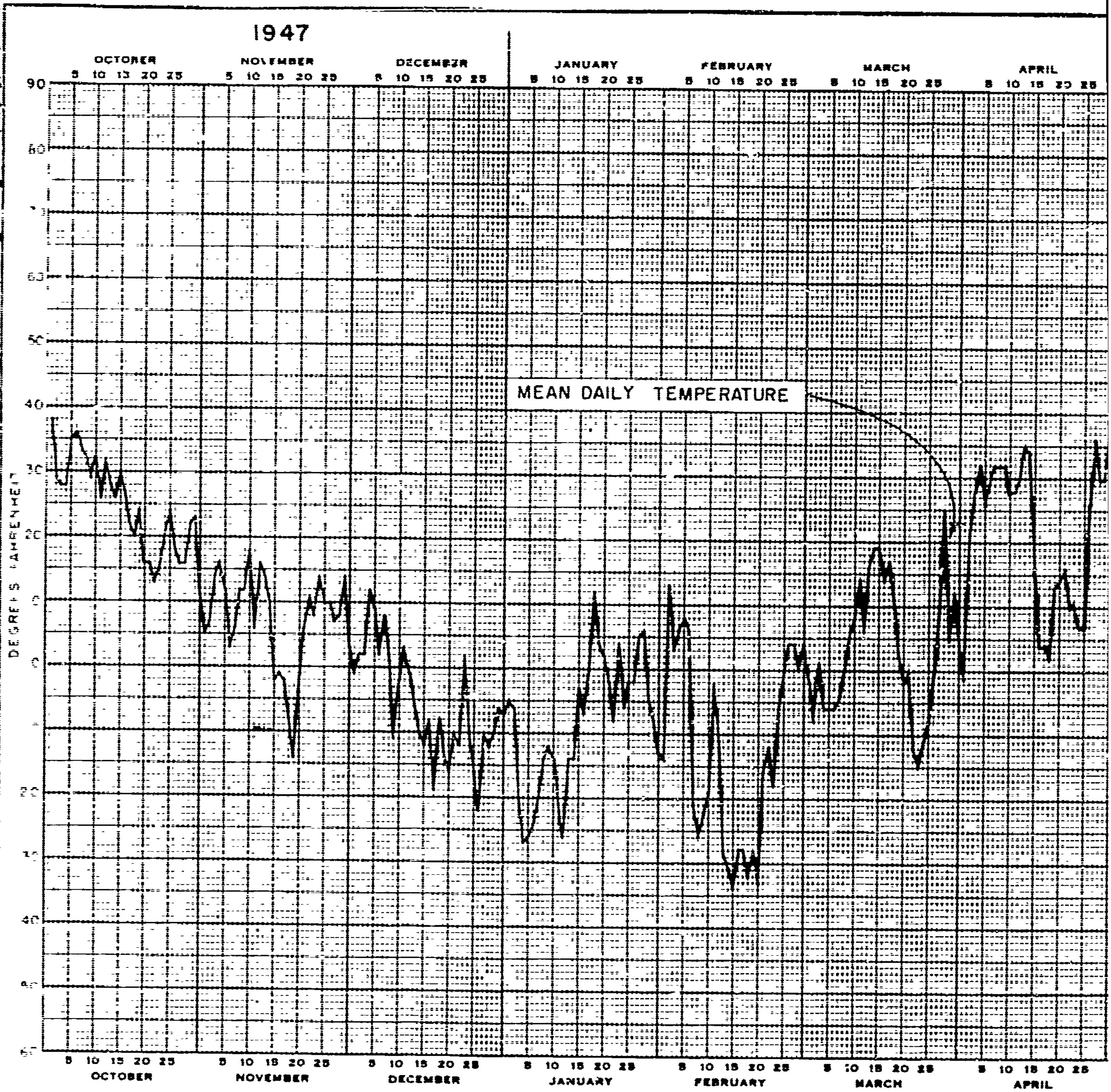


NOTE:
MEAN ANNUAL TEMPERATURE = 23.2° F. (5 YEAR RECORD).
DATA COMPUTED FROM ALASKA SECTION "CLIMATOLOGICAL DATA" BY U. S. WEATHER BUREAU. USING MEAN MONTHLY & SEMIMONTHLY TEMPERATURES.

PERMAFROST INVESTIGATION
METEOROLOGICAL STUDIES
NORTHWAY AIRFIELD, ALASKA
DEGREE DAYS ABOVE & BELOW 32° F

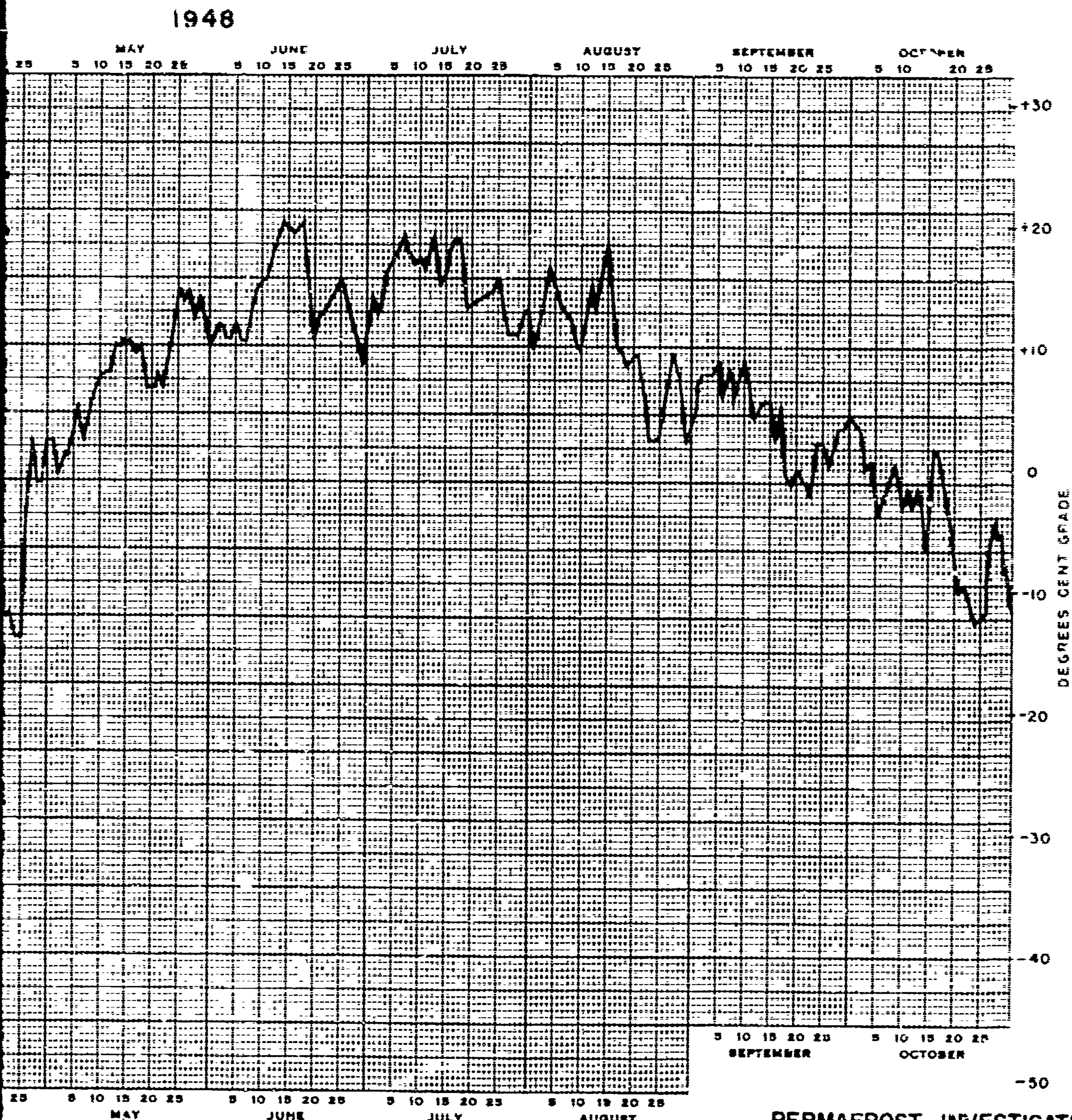
CORPS OF ENGINEERS, ST. PAUL, MINN. MAY 1950

PLATE I-2



1947
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MEAN DAILY TEMPERATURE
DEGREES FAHRENHEIT
90
40
30
20
0

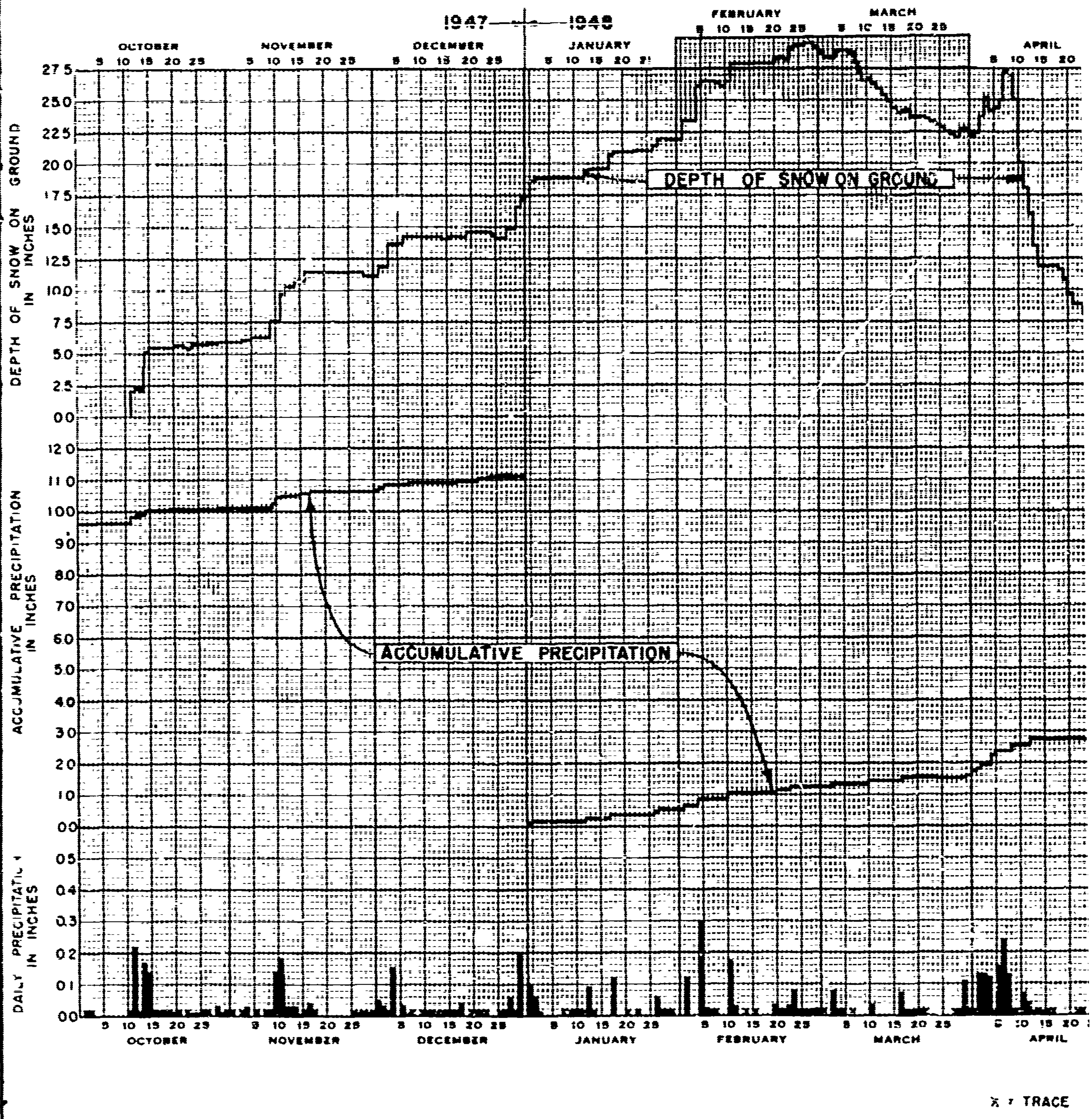
A



PERMAFROST INVESTIGATION
METEOROLOGICAL STUDIES
U.S.W.B. WEATHER STATION
NORTHWAY, ALASKA
AIR TEMPERATURE 1947-1948
CORPS OF ENGINEERS, ST. PAUL, MINN. MAY 1950

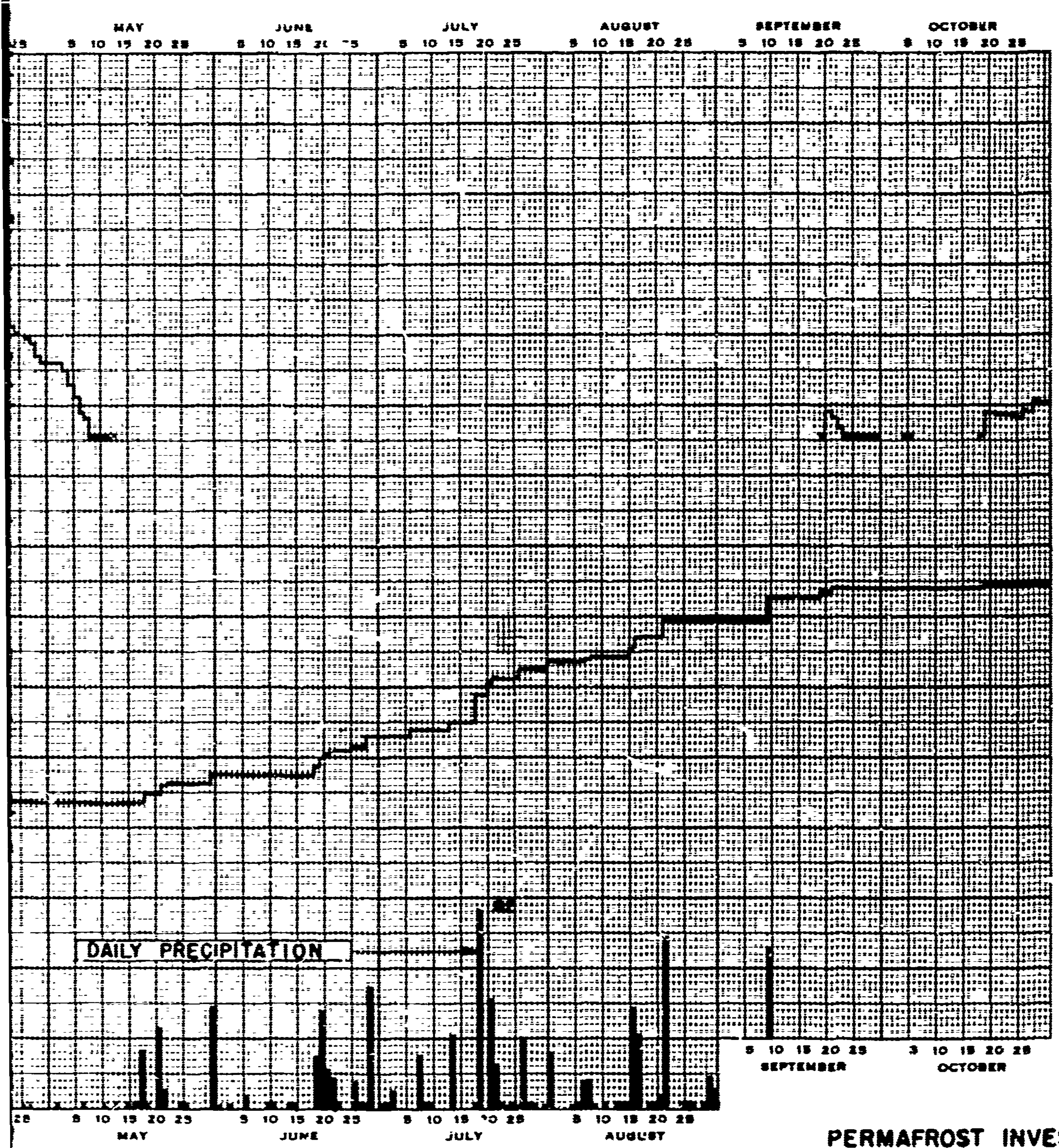
B

PLATE I-3



1947 — 1948
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
DEPTH OF SNOW ON GROUND IN INCHES
DEPTH OF SNOW ON GROUND
ACCUMULATIVE PRECIPITATION IN INCHES
ACCUMULATIVE PRECIPITATION
DAILY PRECIPITATION IN INCHES
X = TRACE

A



PERMAFROST INVESTIGATION

NORTHWAY AIRFIELD, ALASKA

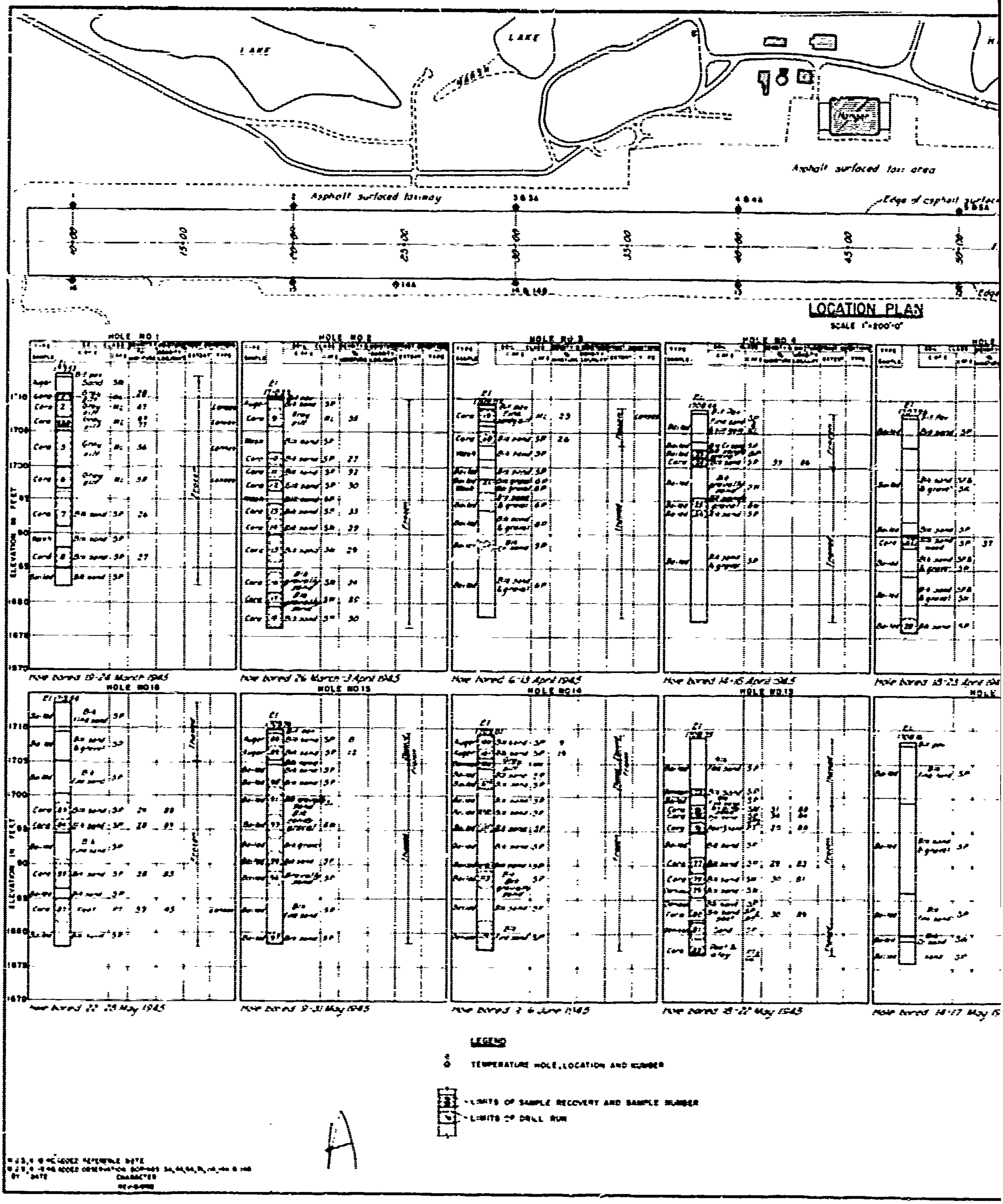
METEOROLOGICAL DATA

PRECIPITATION & SNOW COVER

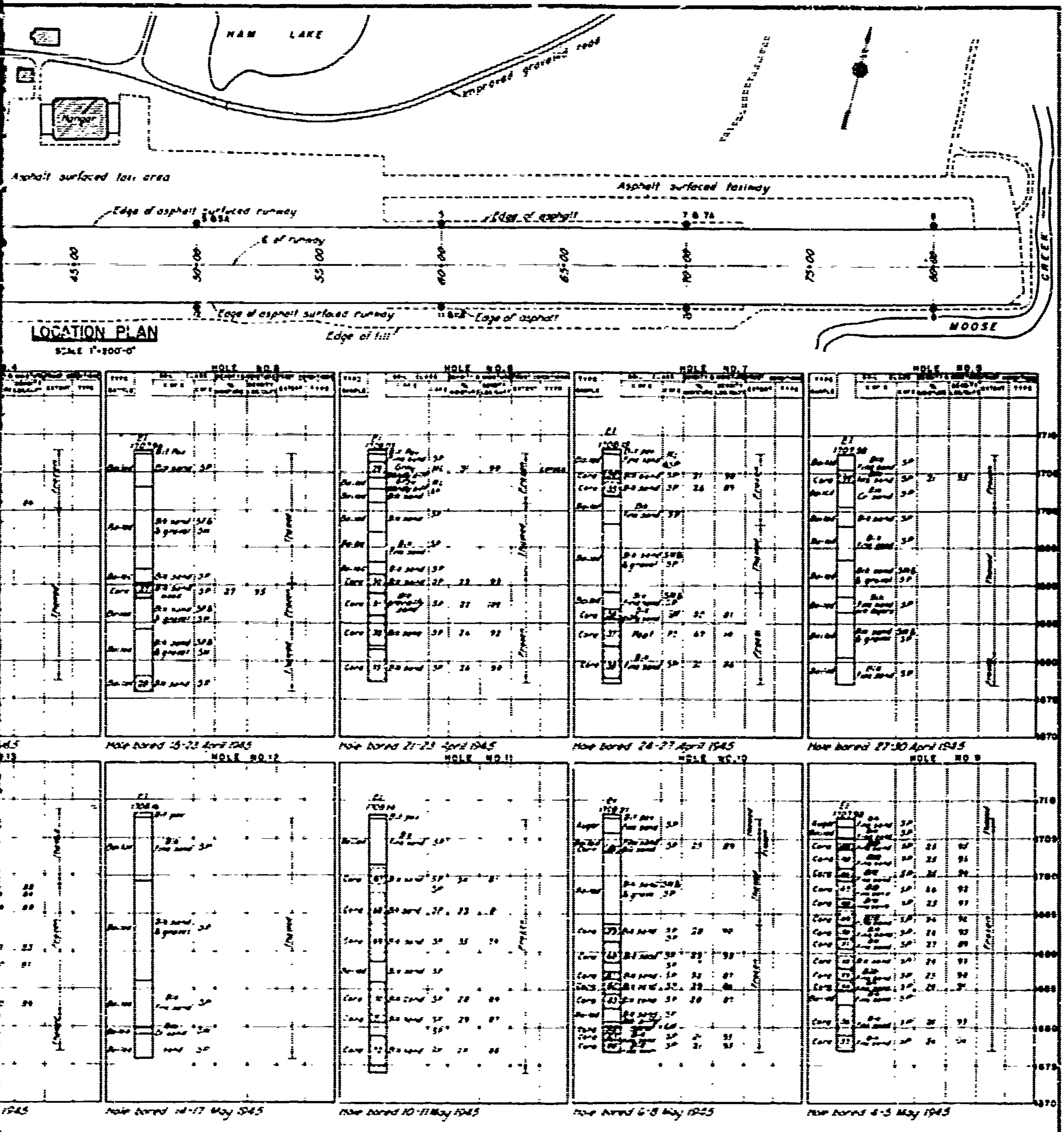
CORPS OF ENGINEERS, ST. PAUL, MINN. MAY 1950

B

PLATE I-4



LAKE
LAKE
MARSH
Hangar
Asphalt surfaced taxi area
Asphalt surfaced taxiway
Edge of asphalt surface
LOCATION PLAN
HOLE NO 1
HOLE NO 2
HOLE NO 3
HOLE NO 4
Hole bored 19-24 March 1945
Hole bored 26 March - 3 April 1945
Hole bored 6-13 April 1945
Hole bored 14-16 April 1945
Hole bored 22-25 May 1945
Hole bored 9-31 May 1945
Hole bored 3-4 June 1945
Hole bored 18-22 May 1945
ELEVATION IN FEET
LEGEND
TEMPERATURE HOLE, LOCATION AND NUMBER
LIMITS OF SAMPLE RECOVERY AND SAMPLE NUMBER
LIMITS OF DRILL RUN



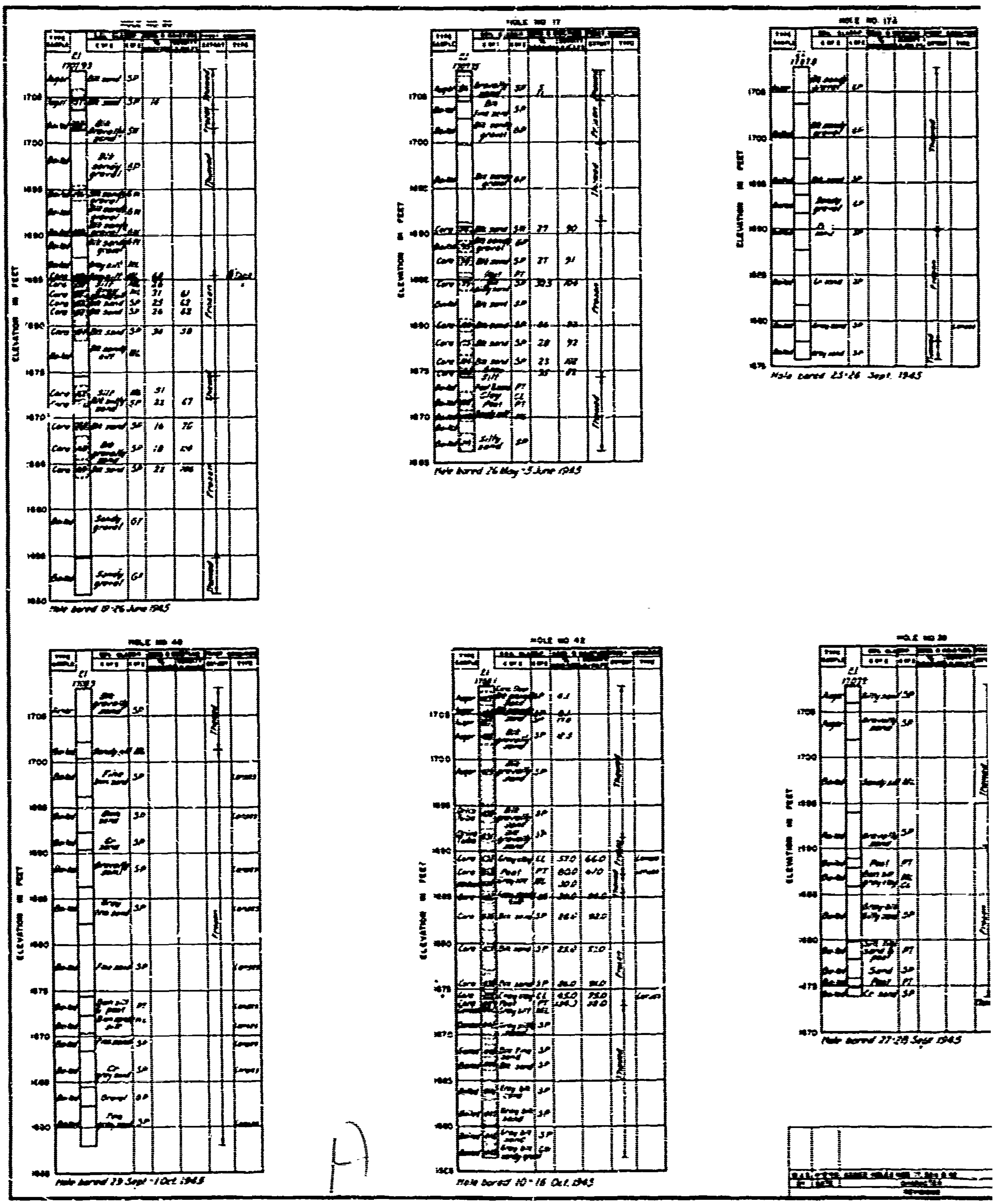
PERMAFROST INVESTIGATION
NORTHWAY AIRFIELD, ALASKA
EXPLORATORY BORINGS
ADJACENT TO RUNWAY

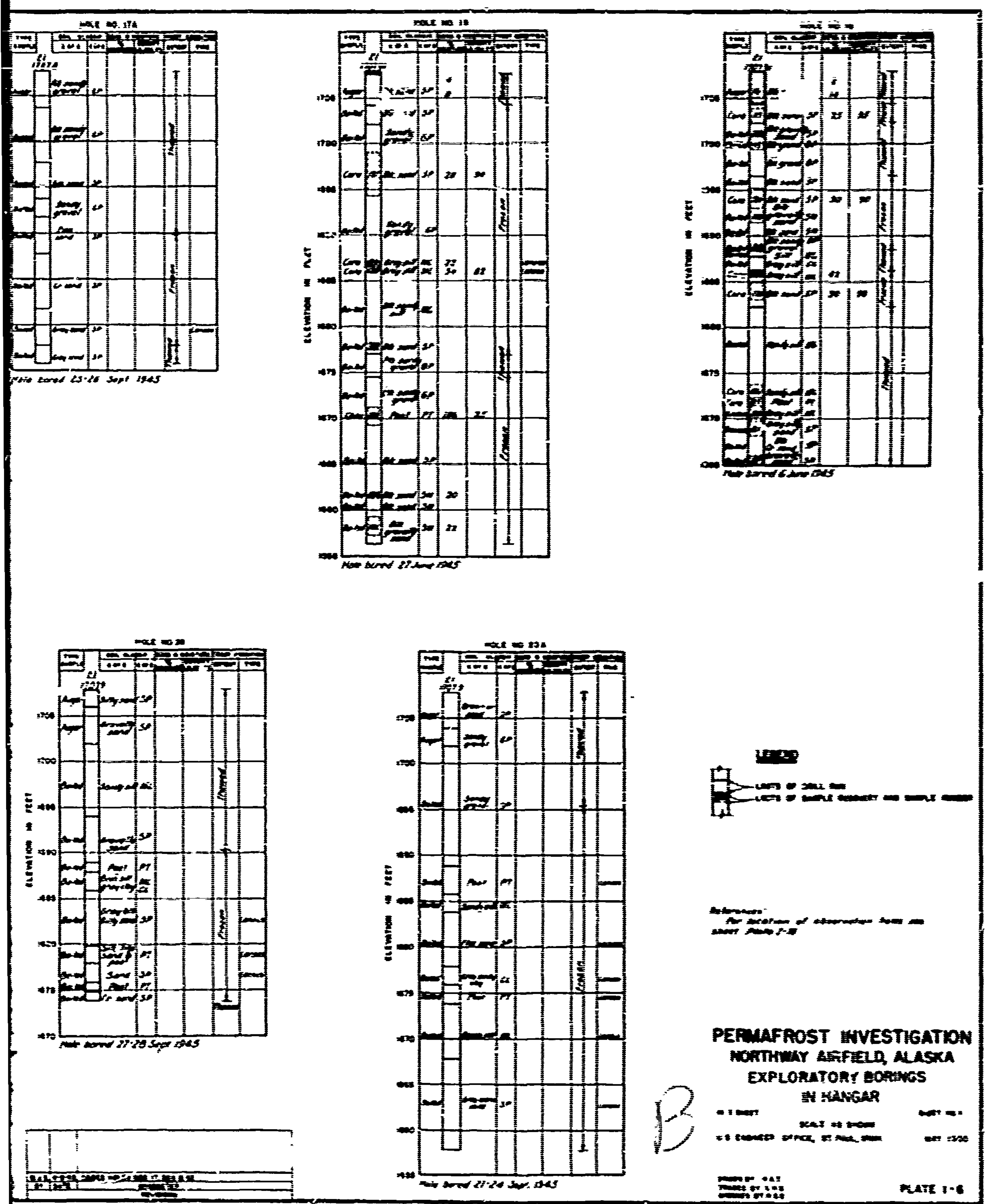
SCALE AS SHOWN

U.S. ENGINEER OFFICE, ST. PAUL, MINN.

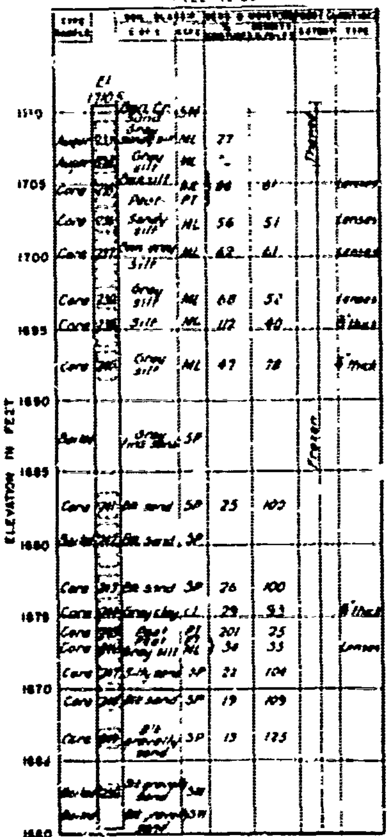
B

PLATE 1-5


HOLE NO 17
HOLE NO 17A
HOLE NO 40
HOLE NO 42
ELEVATION IN FEET
Hole bored 19-26 June 1945
Hole bored 26 May - 5 June 1945
Hole bored 25-26 Sept. 1945
Hole bored 29 Sept - 1 Oct. 1945
Hole bored 10 - 16 Oct. 1945
Hole bored 27-28 Sept 1945

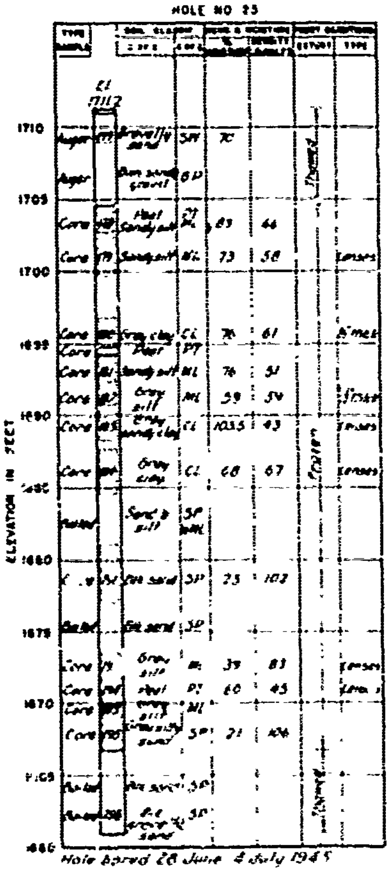

HOLE NO. 17A
HOLE NO. 19
HOLE NO. 20
HOLE NO. 23A
ELEVATION IN FEET
Hole bored 25-26 Sept 1945
Hole bored 27 June 1945
Hole bored 6 June 1945
Hole bored 27-28 Sept 1945
Hole bored 27-24 Sept 1945
LEGEND
PERMAFROST INVESTIGATION
NORTHWAY AIRFIELD, ALASKA
EXPLORATORY BORINGS
IN HANGAR
PLATE I-6

HOLE NO 26



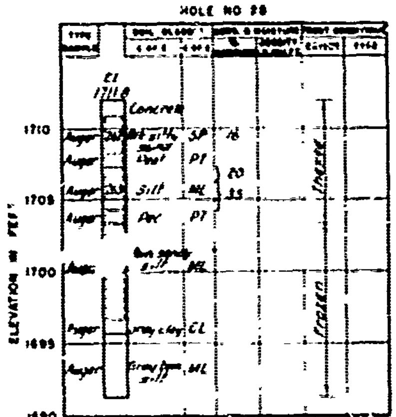
Hole bored 20-26 July 1945

HOLE NO 25

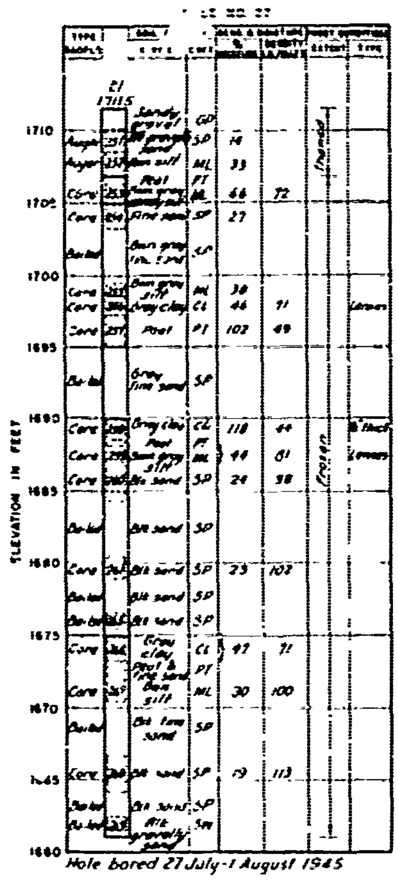


Hole bored 28 June - 4 July 1945

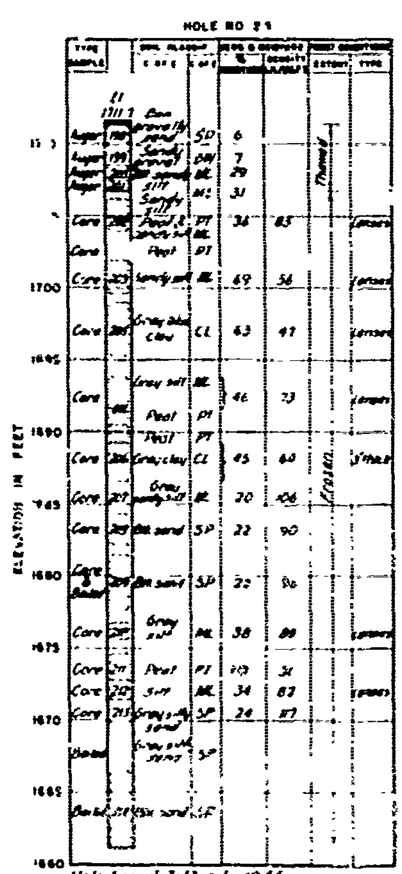
HOLE NO 28



Hole bored 30 July - 1 August 1945

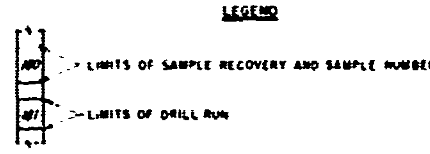


Hole bored 27 July-1 August 1945



Hole bored 7-12 July 1945

LEGEND



References
for location of observation holes see Plate I-20

PERMAFROST INVESTIGATION
NORTHWAY AIRFIELD, ALASKA
EXPLORATORY BORINGS IN AND ADJACENT TO MOTORPOOL BUILDING

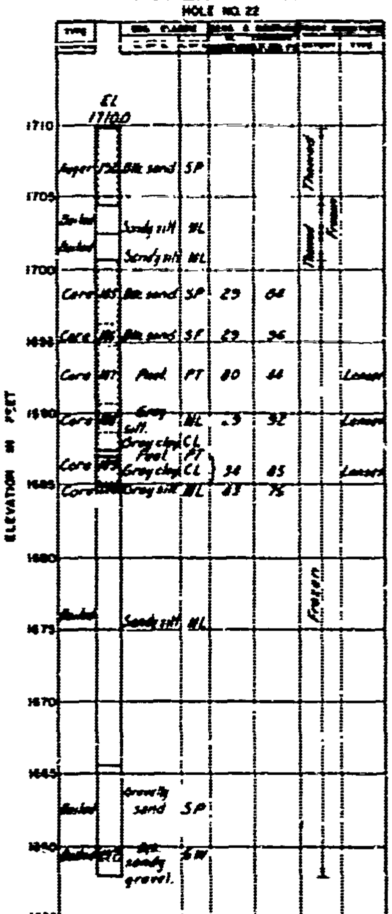
IN 1 SHEET SHEET NO 1
SCALE AS SHOWN
US ENGINEER OFFICE, ST PAUL, MINN MAY 1950

B

DRAWN BY R.A.T.
TRACED BY L.H.S.
CHECKED BY

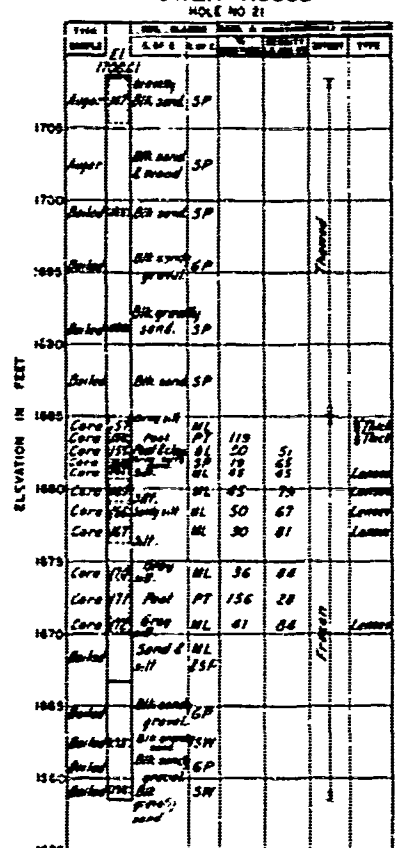
PLATE I-7

POWER HOUSE
HOLE NO. 22



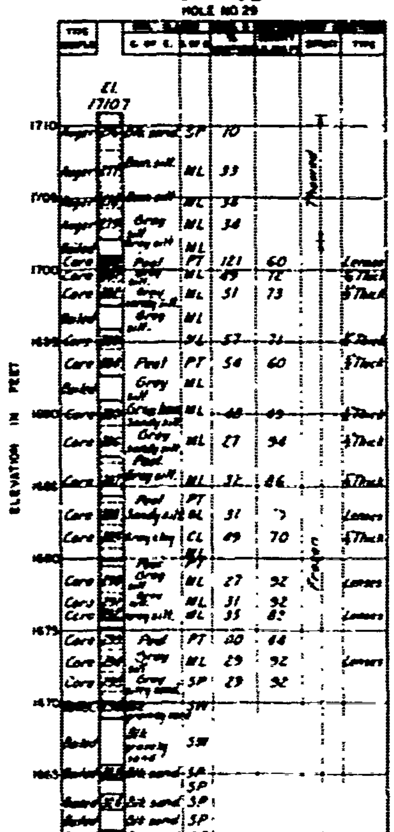
Hole bored 29 June - 25 July 1945.

POWER HOUSE
HOLE NO. 21



Hole bored 20-27 June 1945.

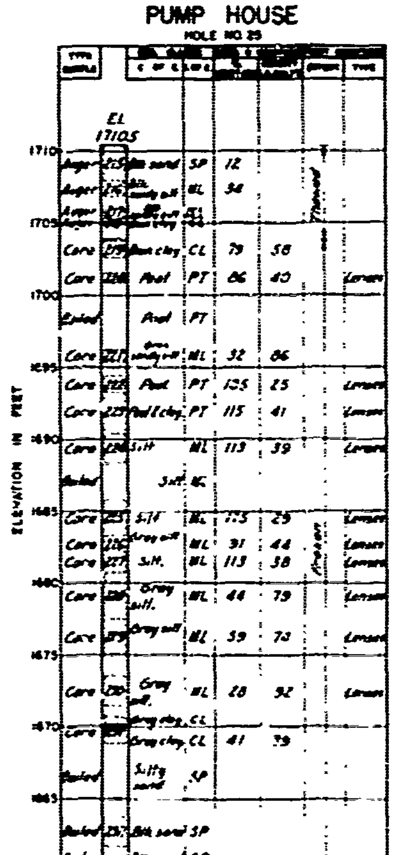
GARAGE
HOLE NO. 29



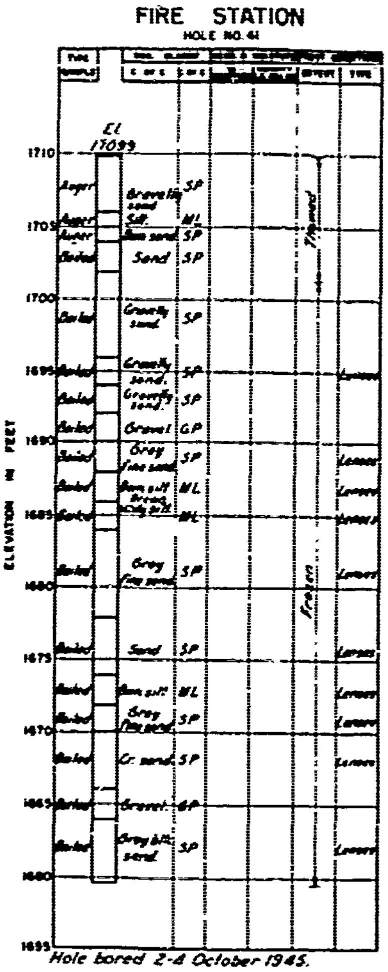
Hole bored 11 August - 17 August 1945

A

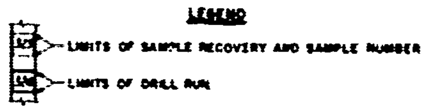
PUMP HOUSE
HOLE NO. 25

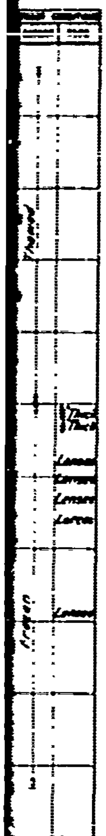


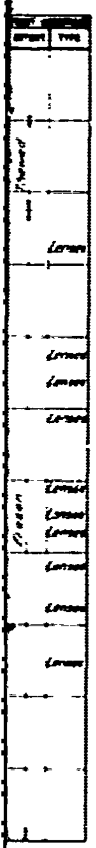
Hole bored 14-18 July 1945



Hole bored 2-4 October 1945.







References:
For location of observation holes at Power House see plate I-21
For location of observation hole at Fire Station see plate I-23
For location of observation hole at Garage see plate I-22
For location of observation hole at Pump House see plate I-24

B

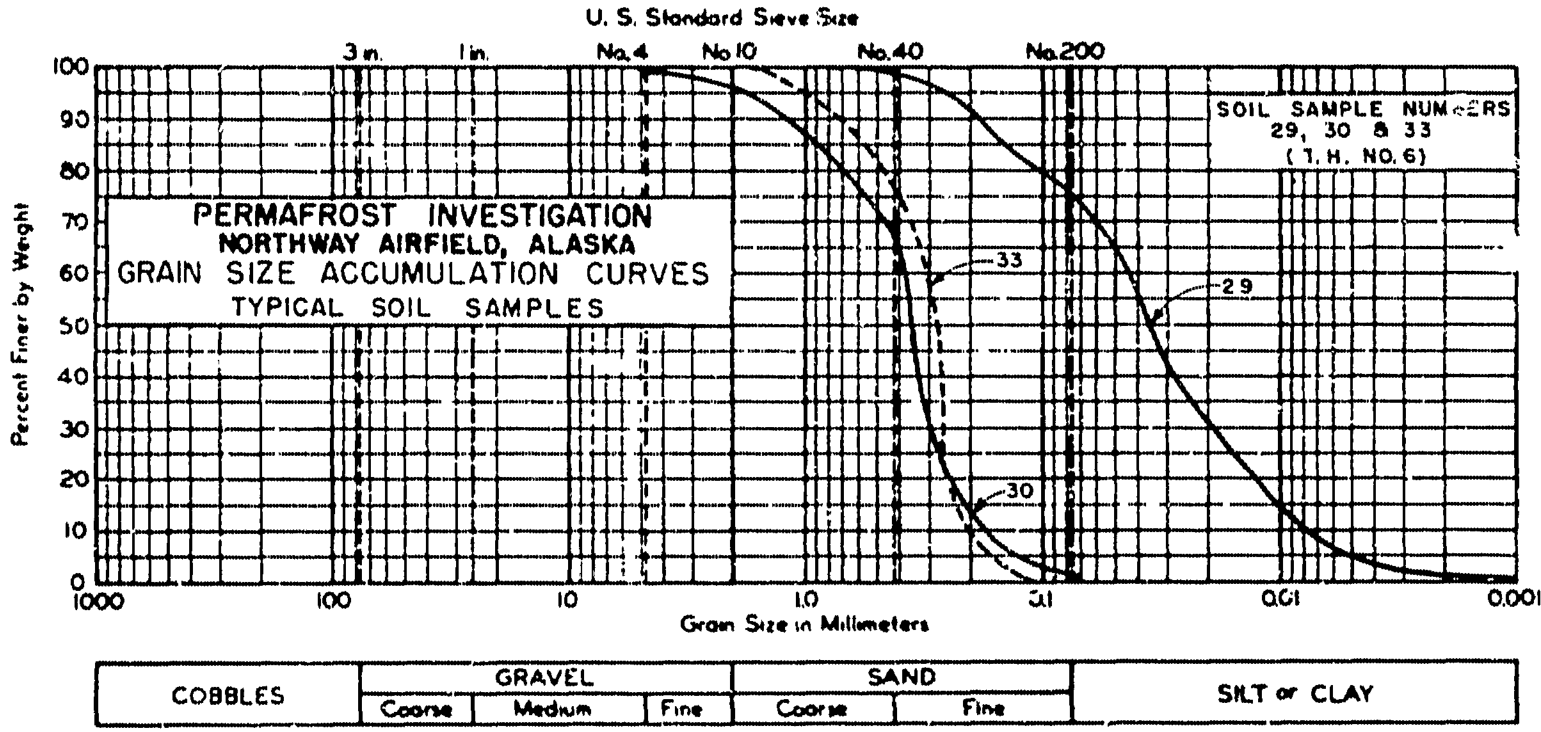
PERMAFROST INVESTIGATION
NORTHWAY AIRFIELD, ALASKA
EXPLORATORY BORINGS IN MISCELLANEOUS BUILDINGS

IN 1 SHEET — SHEET NO. 1
SCALE AS SHOWN
U.S. ENGINEER OFFICE, ST. PAUL, MINN. MAY 1950

DRAWN BY H.A.T.
TRACED BY G.P.A.
CHECKED BY

PLATE I-8

MECHANICAL ANALYSIS



Number	Natural % Moisture	LL	PL	PI	Classification	Remarks
29	31	-	-	-	Sandy Silt M.L.	Nonplastic
30	23	-	-	-	Sand SP	"
33	26	-	-	-	" "	"

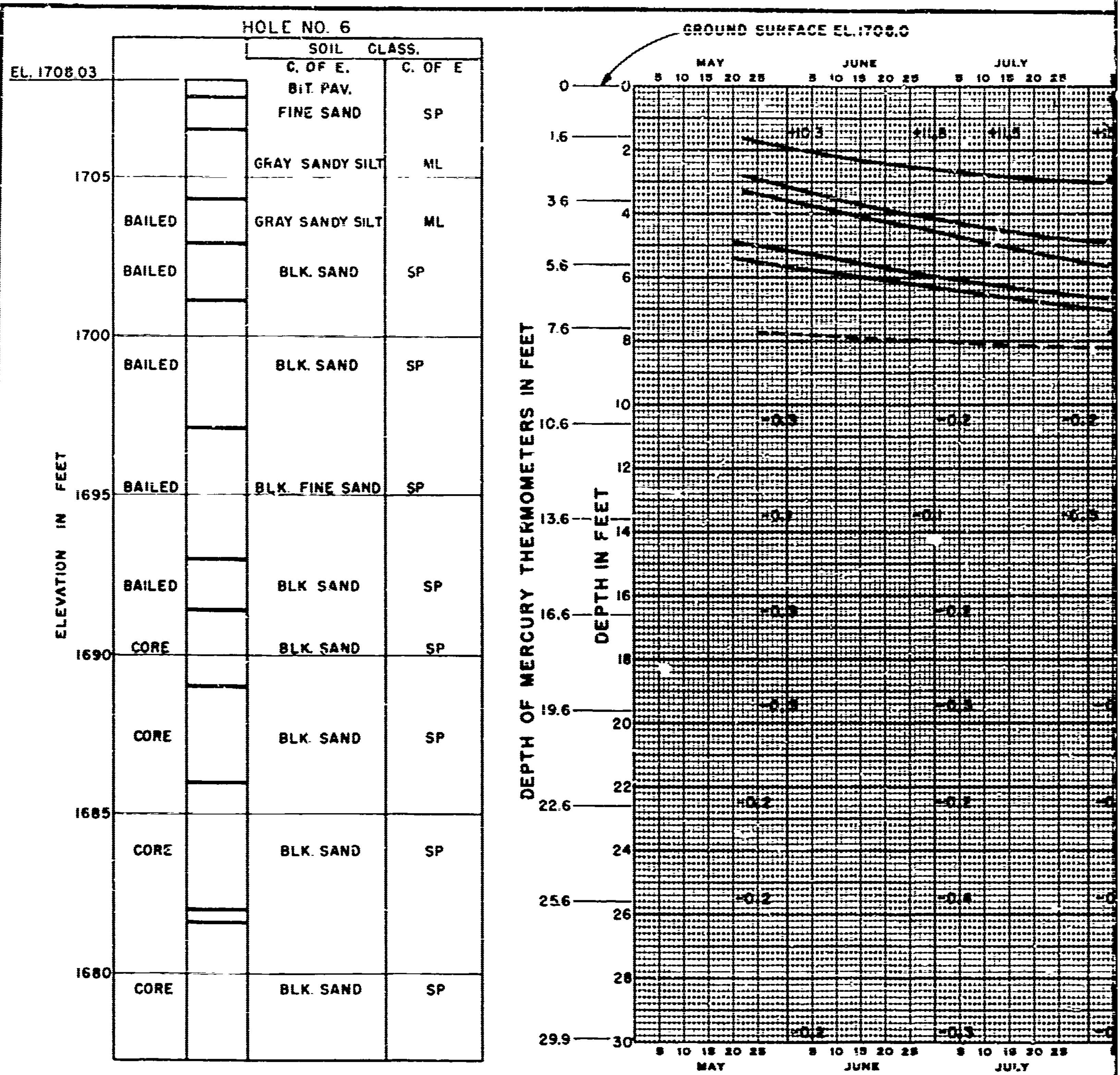
SOILS LABORATORY
PERMAFROST
NORTHWAY AIRFIELD, ALASKA

PROJECT Northway Airfield Inv.
AREA No. Edge of Runway
LOCATION Sta. 60+00 HOLE NO. Temp. #6
PLOTTED BY ______ CHECKED BY ______

WD FORM 305
7 NOV 49

MAY 1950

PLATE I-9

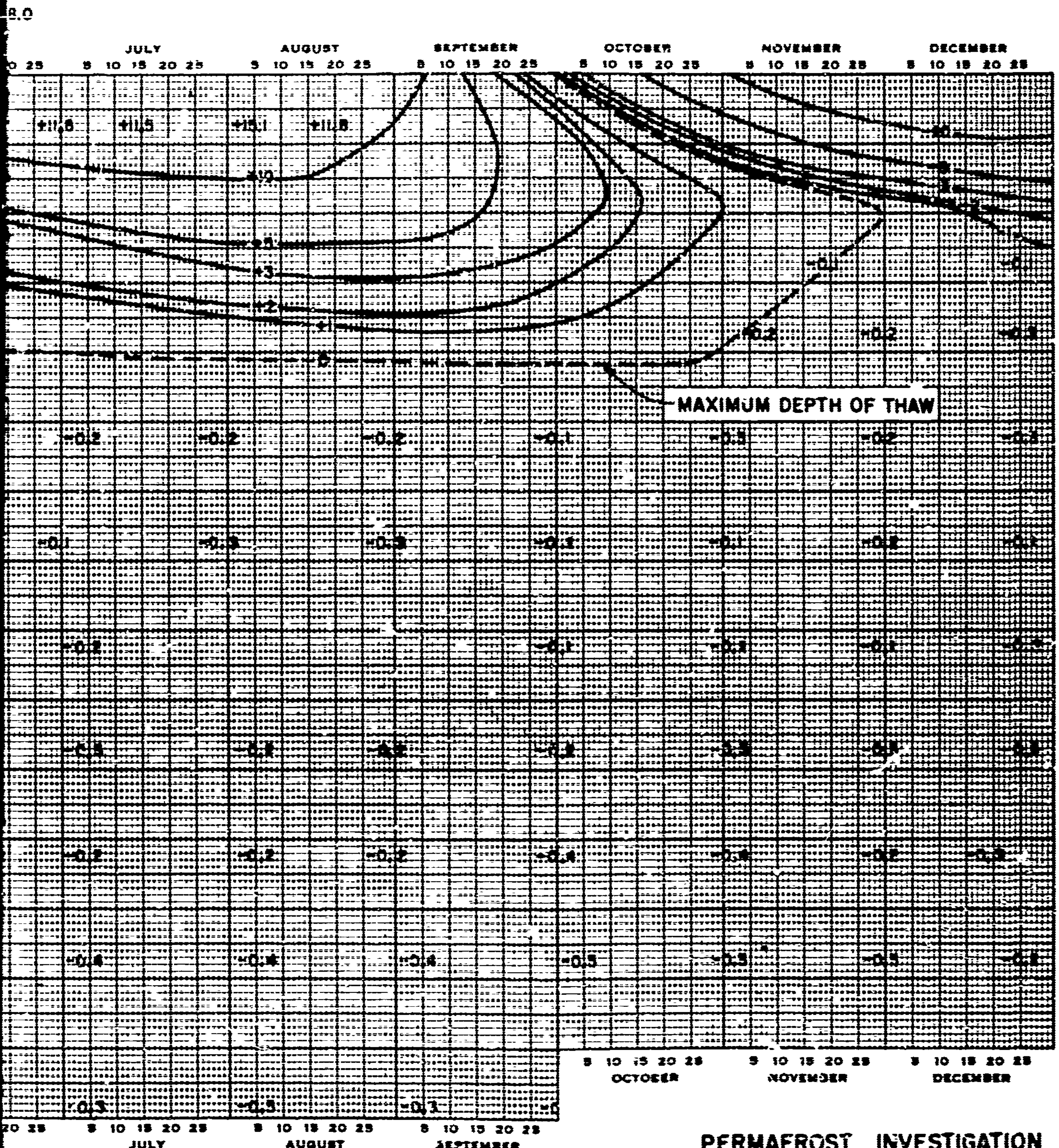


LEGEND

- - - - - ZERO ISOTHERM

——— ISOTHERMS OTHER THAN ZERO (ABOVE OR BELOW AS MARKED)

GENERAL NO
ISOTHERMS
LOCATION
SHOWN



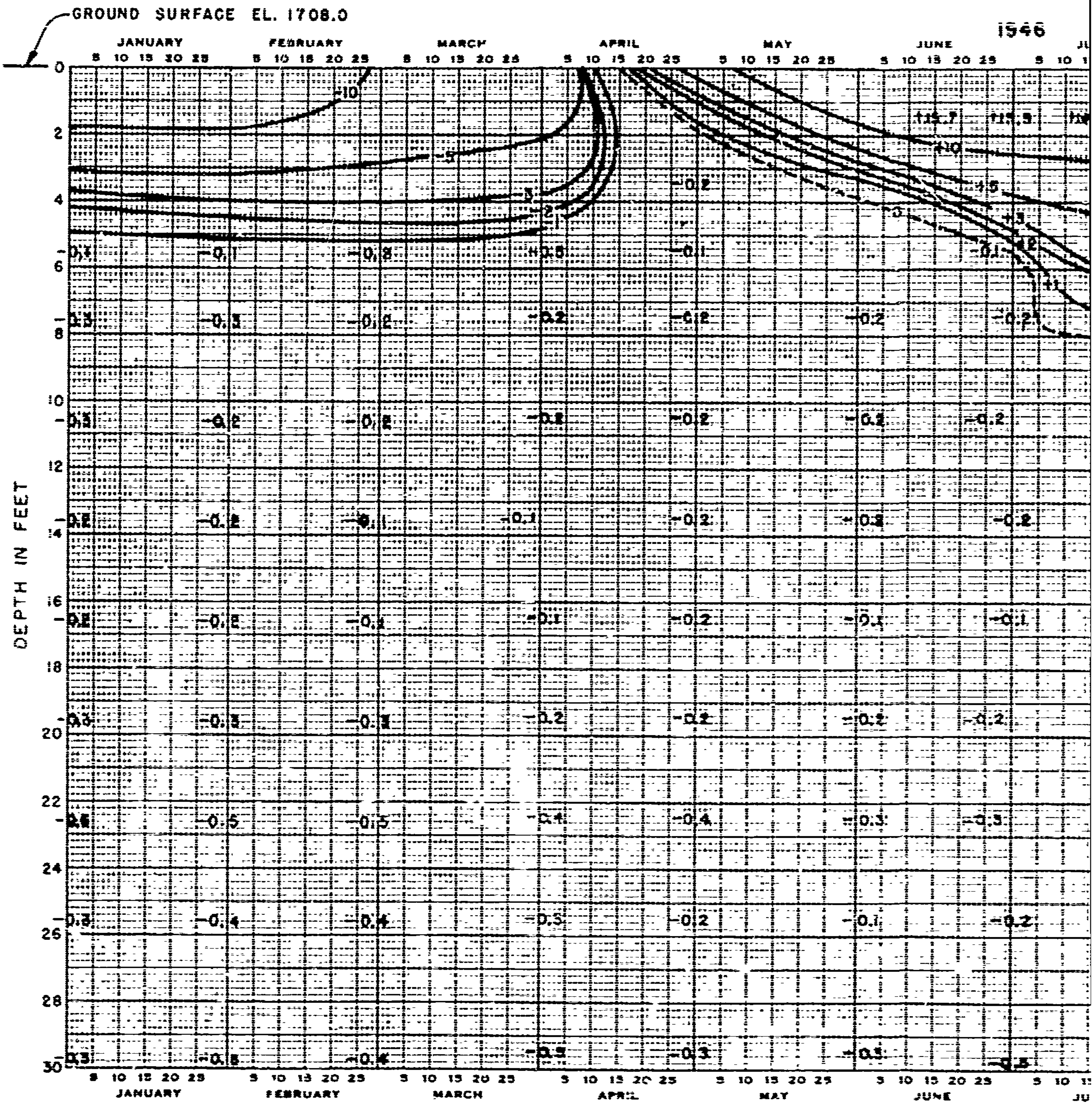
PERMAFROST INVESTIGATION
NORTHWAY AIRFIELD, ALASKA
RUNWAY
GROUND ISOTHERMS
HOLE NO. 6, 1945
CORPS OF ENGINEERS, ST. PAUL, MINN. MAY 1950

GENERAL NOTES:

ISOTHERMS SHOWN IN DEGREES CENTIGRADE.
LOCATION OF GROUND TEMPERATURE HOLE SHOWN ON PLATE I-5

P

PLATE I-10

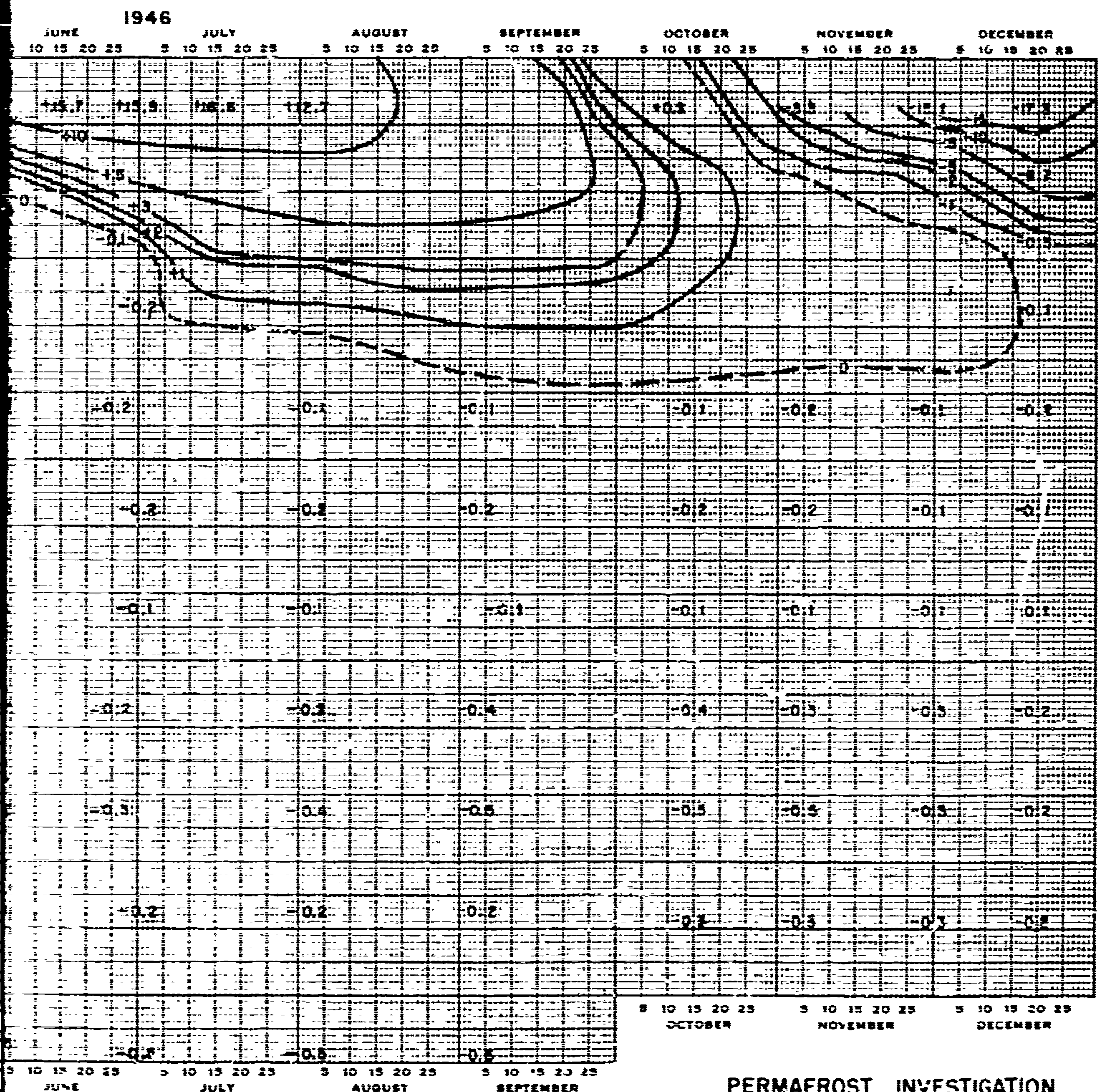


LEGEND

- - - - - ZERO ISOTHERM

——— ISOTHERMS OTHER THAN ZERO (ABOVE OR BELOW AS MARKED)

A



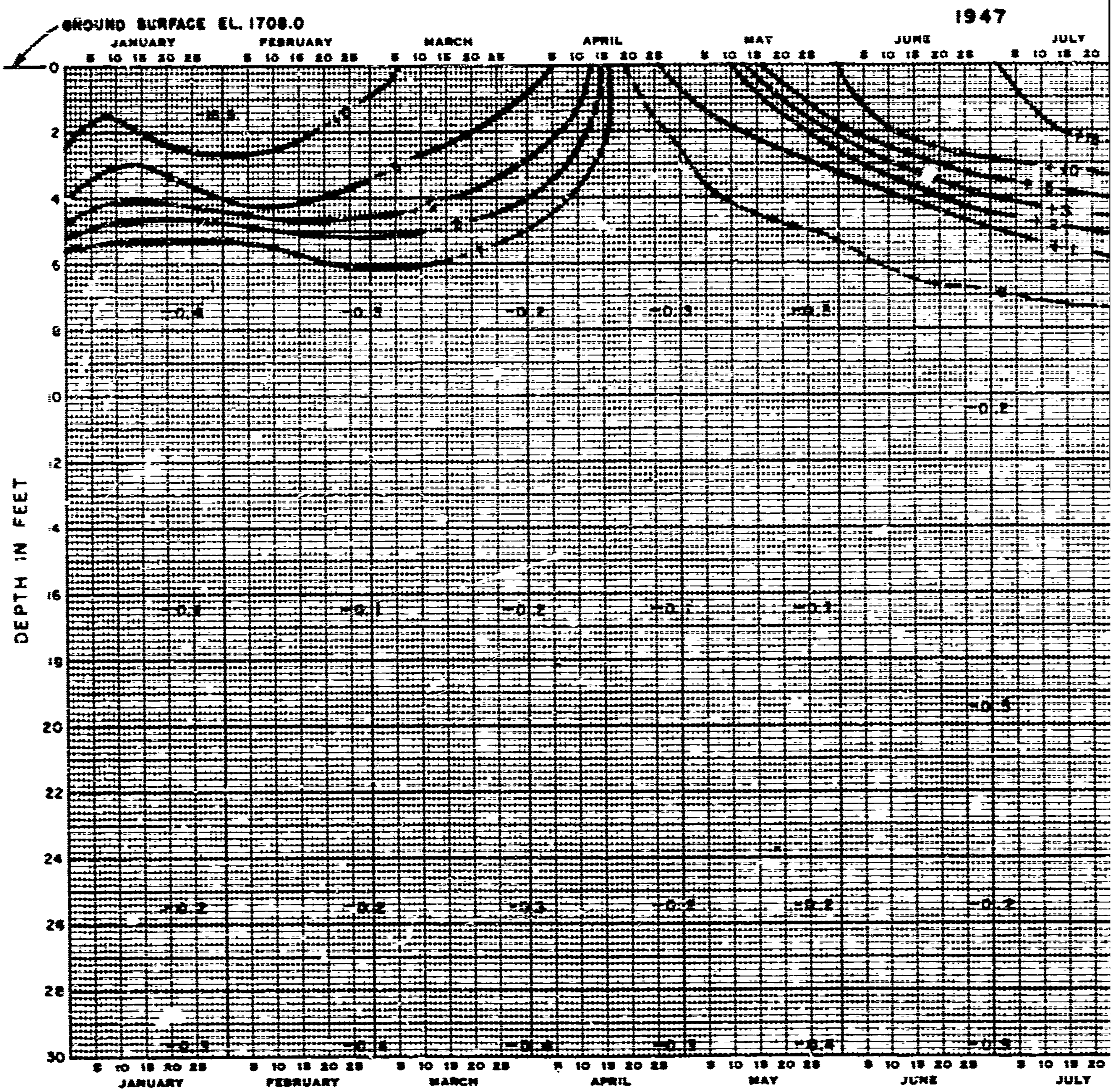
PERMAFROST INVESTIGATION
NORTHWAY AIRFIELD, ALASKA
RUNWAY
GROUND ISOTHERMS
HOLE NO. 6, 1946
U.S. ENGR. OFFICE ST. PAUL, MINN. MAY 1950

GENERAL NOTES:

ISOTHERMS SHOWN IN DEGREES CENTIGRADE.
LOCATION OF GROUND TEMPERATURE HOLE SHOWN ON PLATE I-5

B

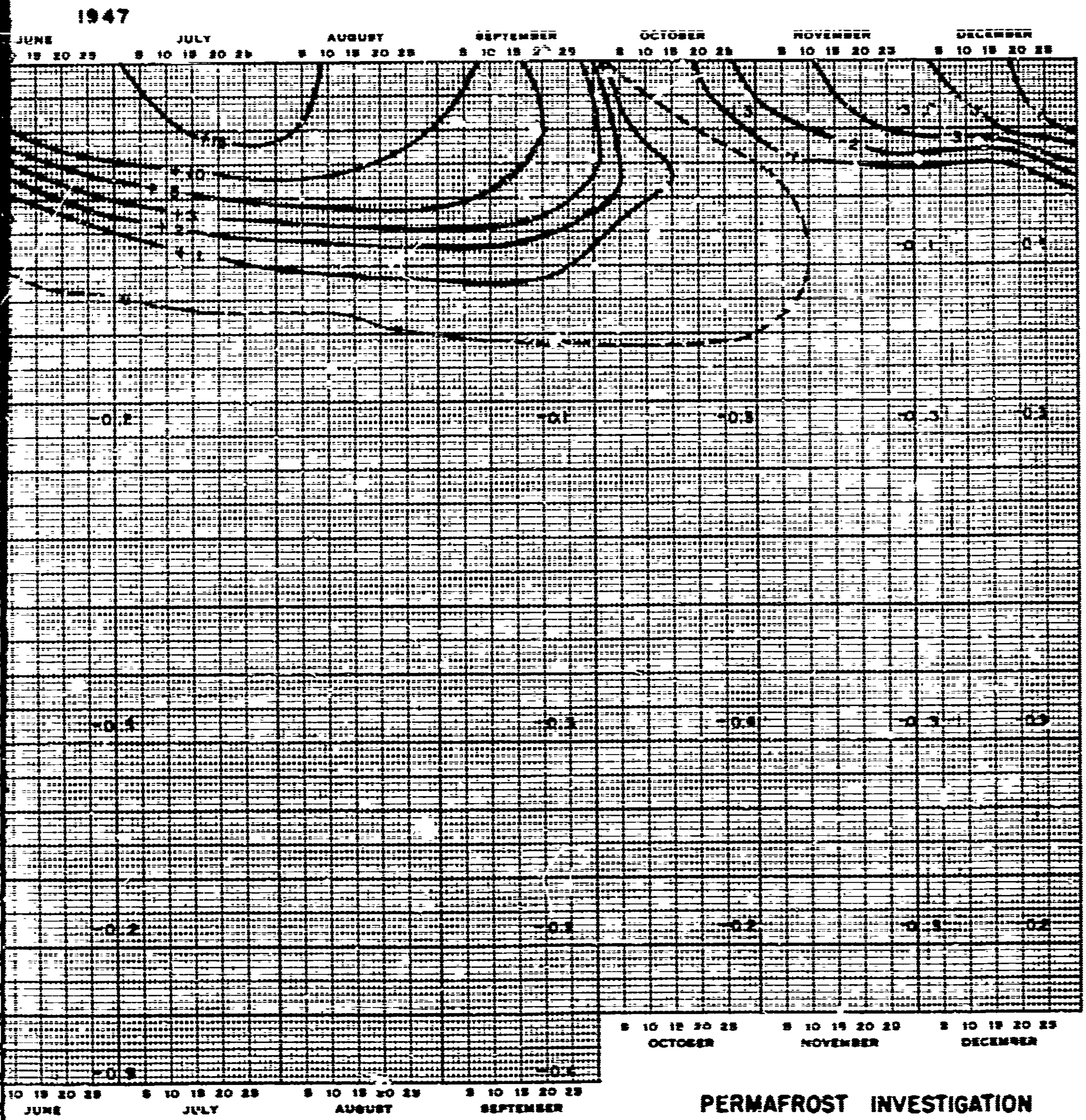
PLATE I-11



LEGEND

- - - - - ZERO ISOTHERM
———— ISOTHERMS OTHER THAN ZERO
(ABOVE OR BELOW AS MARKED)

GENERAL
ISOTHE
LOCATI
SHO



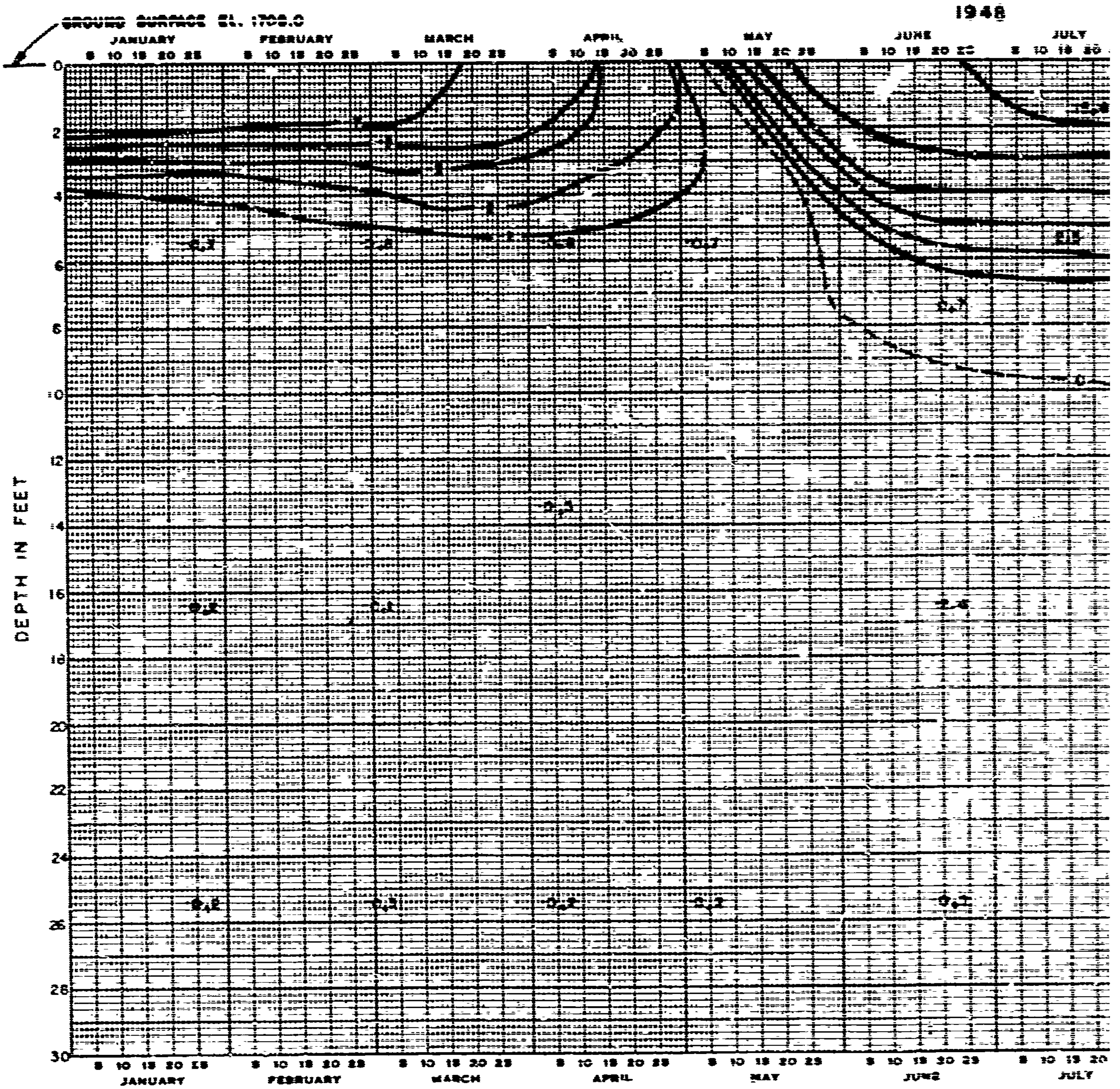
PERMAFROST INVESTIGATION
NORTHWAY AIRFIELD, ALASKA
RUNWAY
GROUND ISOTHERMS
HOLE NO. 6 1947

U.S. ENGR. OFFICE ST. PAUL, MINN. MAY 1950

GENERAL NOTES:

ISOTHERMS SHOWN IN DEGREES CENTIGRADE.
LOCATION OF GROUND TEMPERATURE HOLE SHOWN ON PLATE I-5

PLATE I-12



LEGEND

- - - - - ZERO ISOTHERM

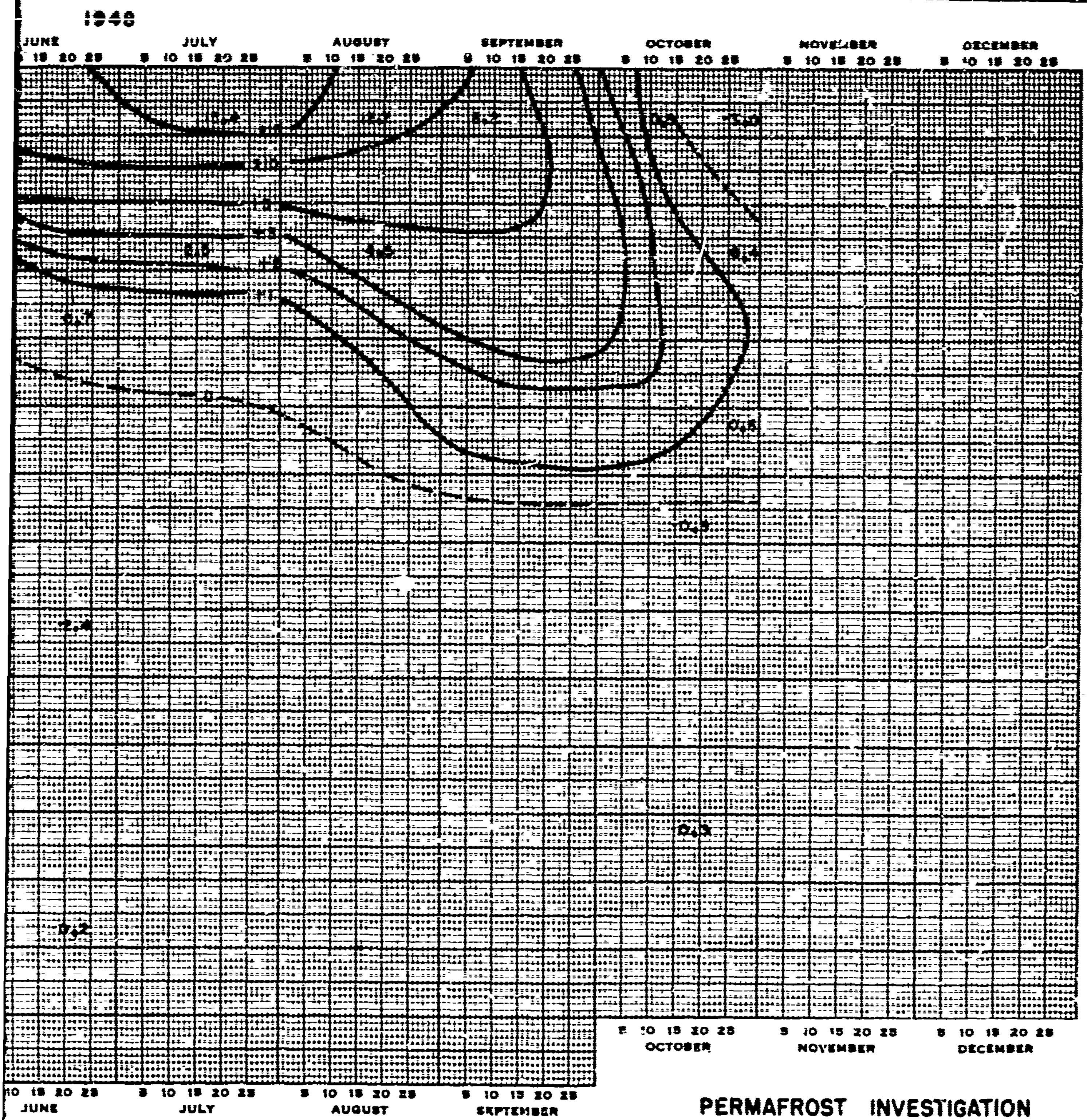
———— ISOTHERMS OTHER THAN ZERO (ABOVE OR BELOW AS MARKED)

GENERAL

ISOTHE

LOCATI

SHO



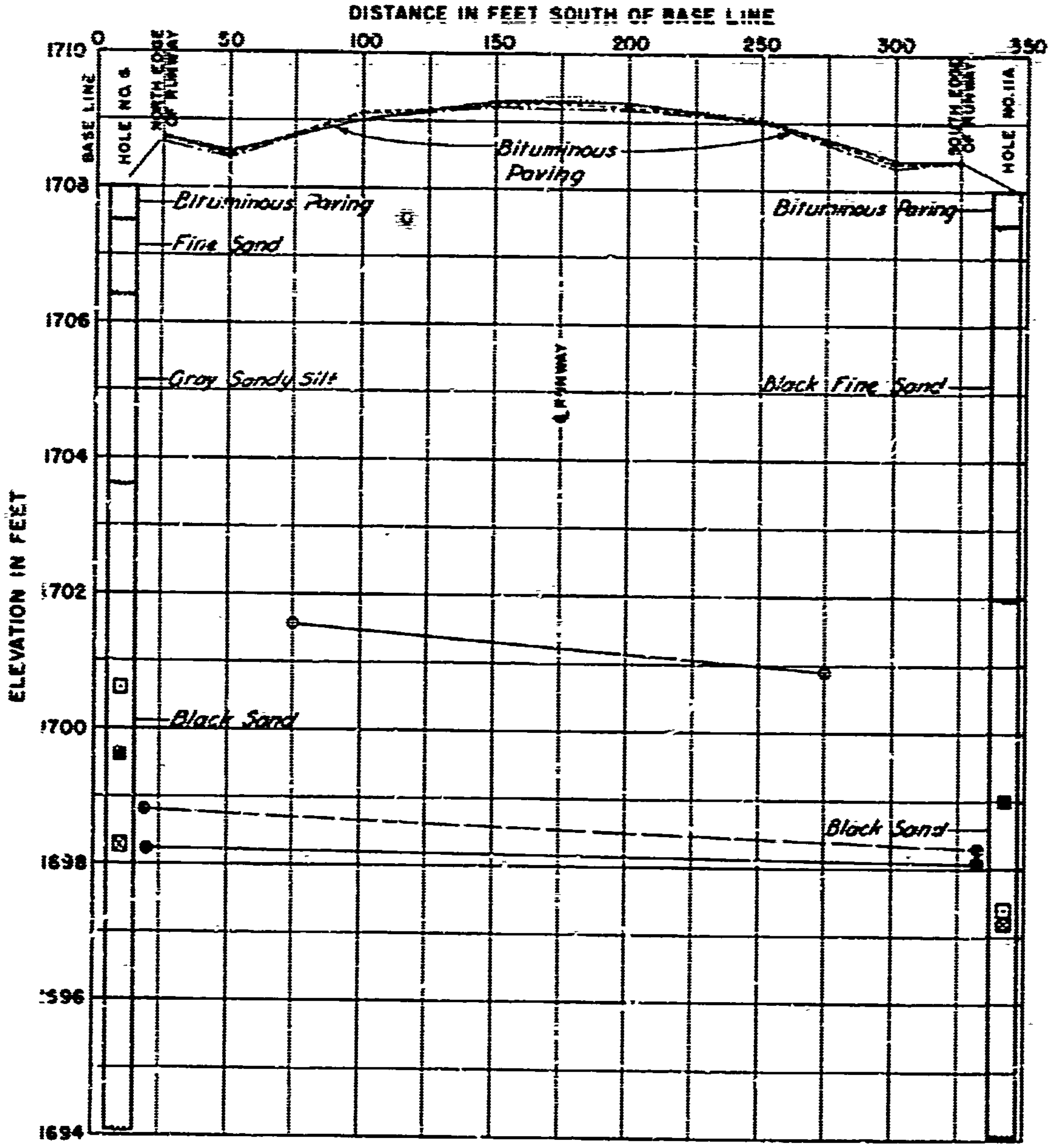
PERMAFROST INVESTIGATION
NORTHWAY AIRFIELD, ALASKA
RUNWAY
GROUND ISOTHERMS
HOLE NO. 6 1948
U.S. ENGR. OFFICE ST. PAUL, MINN. MAY 1950

GENERAL NOTES:

ISOTHERMS SHOWN IN DEGREES CENTIGRADE.
LOCATION OF GROUND TEMPERATURE HOLE SHOWN ON PLATE I-5

B

PLATE I-13



* BEFORE RECONSTRUCTION
** AFTER RECONSTRUCTION

LEGEND

SURFACE ELEVATIONS
- ———— 4-16-45*
- —·—·— 8-16-45**
- - - - - - 3-23-46

PROBINGS
- ○ 10-6-45
- ● 10-24-46
- ● 10-31-47

0°C. ISOTHERM
- ⊡ 10-15-45
- ⊠ 10-16-46
- ■ 10-5-47

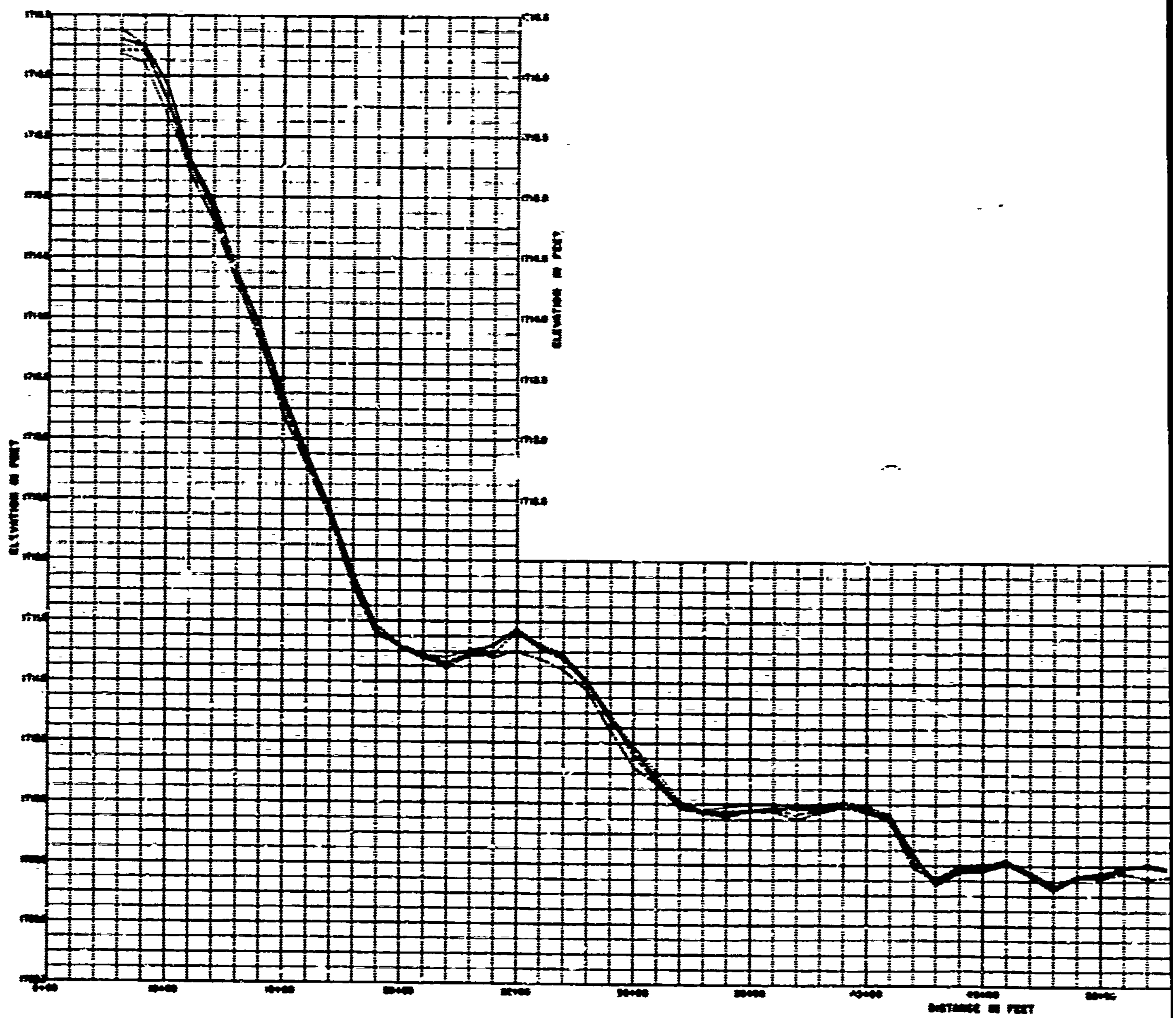
PERMAFROST INVESTIGATION
NORTHWAY AIRFIELD, ALASKA
RUNWAY CROSS SECTIONS
STATION 60+00

SHOWING SURFACE ELEVATIONS, PROBING DEPTHS & 0° C. TEMPERATURES

IN 1 SHEET SHEET NO. 1

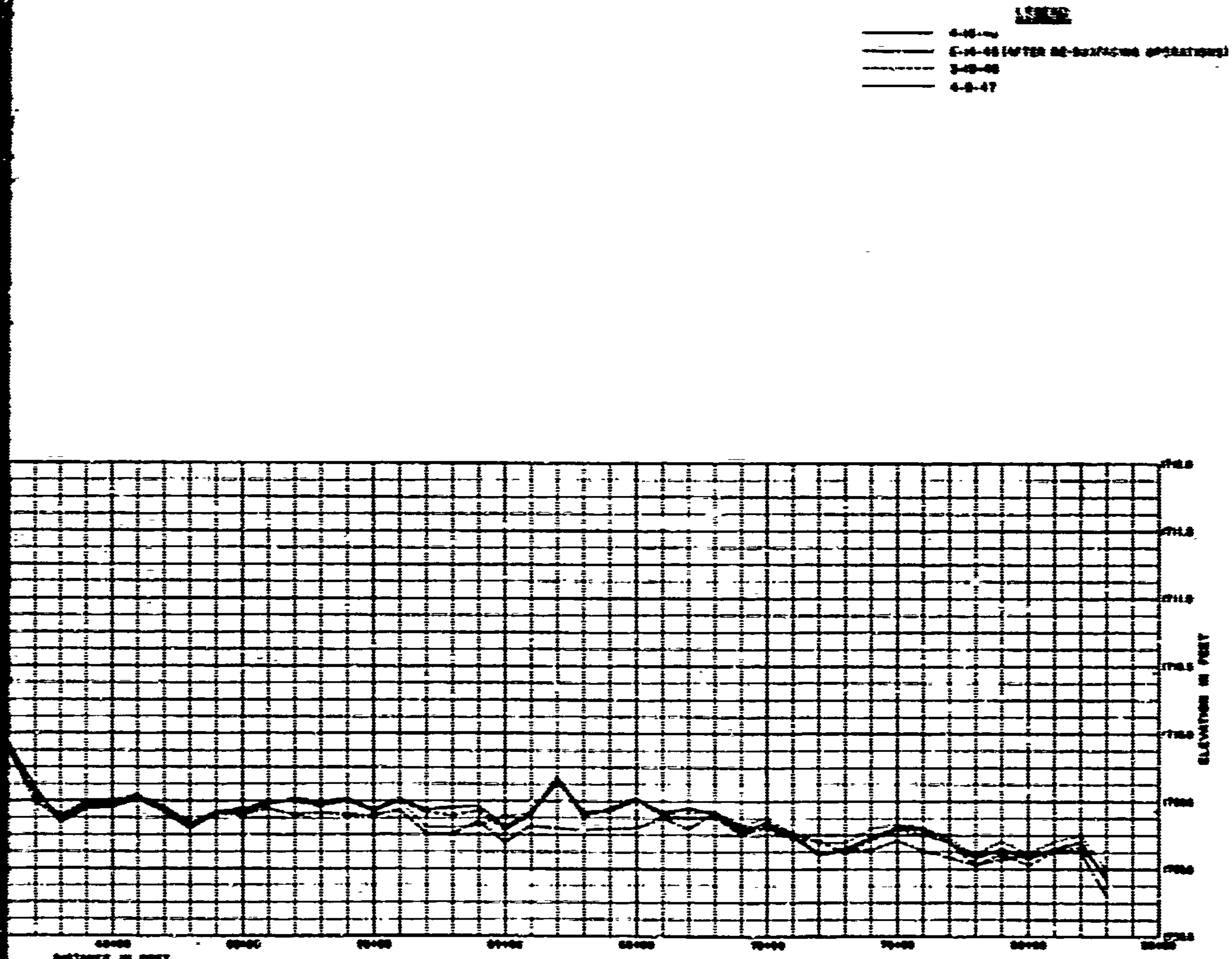
CORPS OF ENGINEERS, ST. PAUL MINN. MAY 1950

PLATE I-14



PROFILE
ON ℄ OF RUNWAY

A



PROFILE
ON ℄ OF RUNWAY

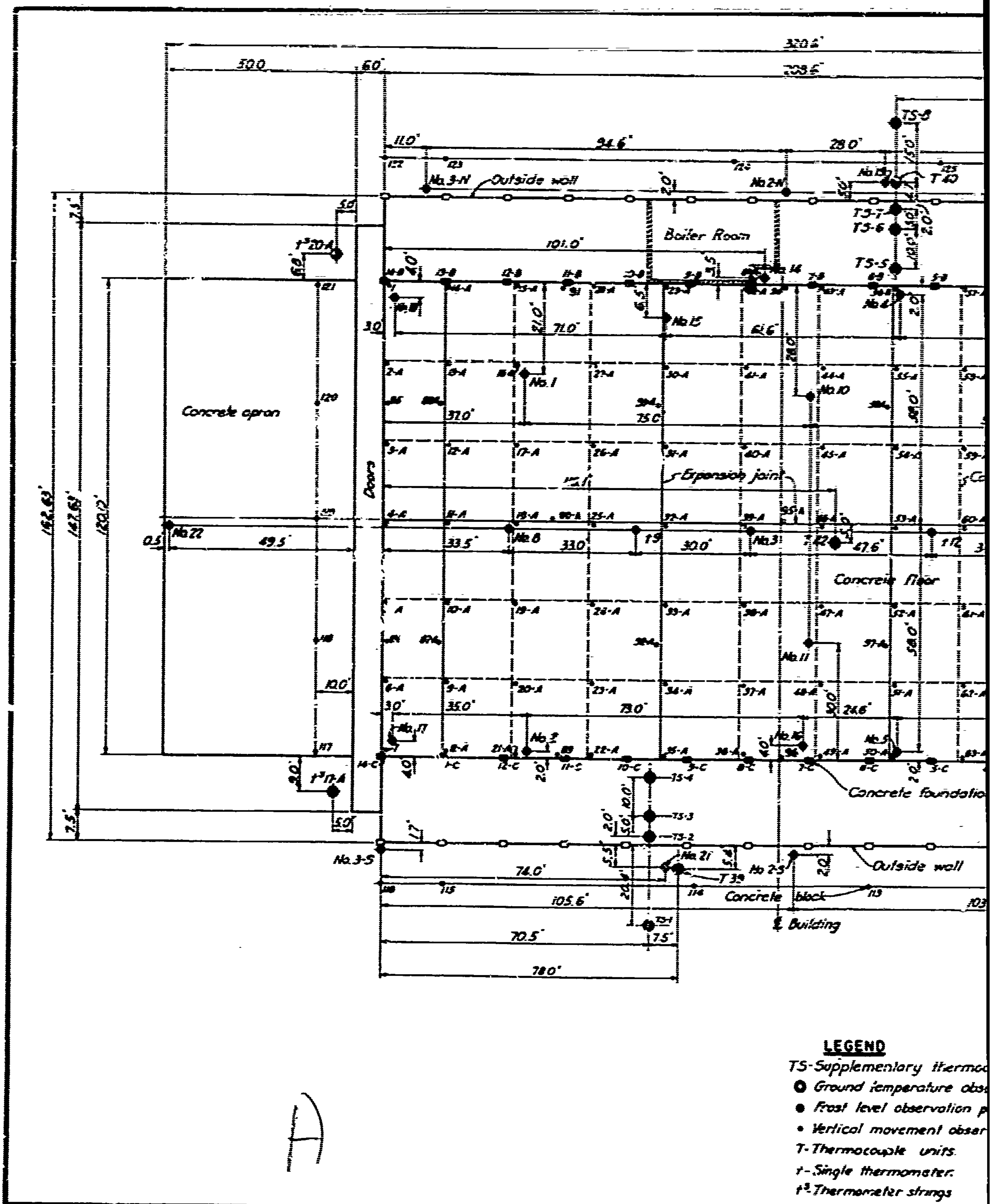
PERMAFROST INVESTIGATION
NORTHWAY AIRFIELD, ALASKA
LONGITUDINAL SETTLEMENT
PROFILE-℄ OF RUNWAY

SCALE AS SHOWN

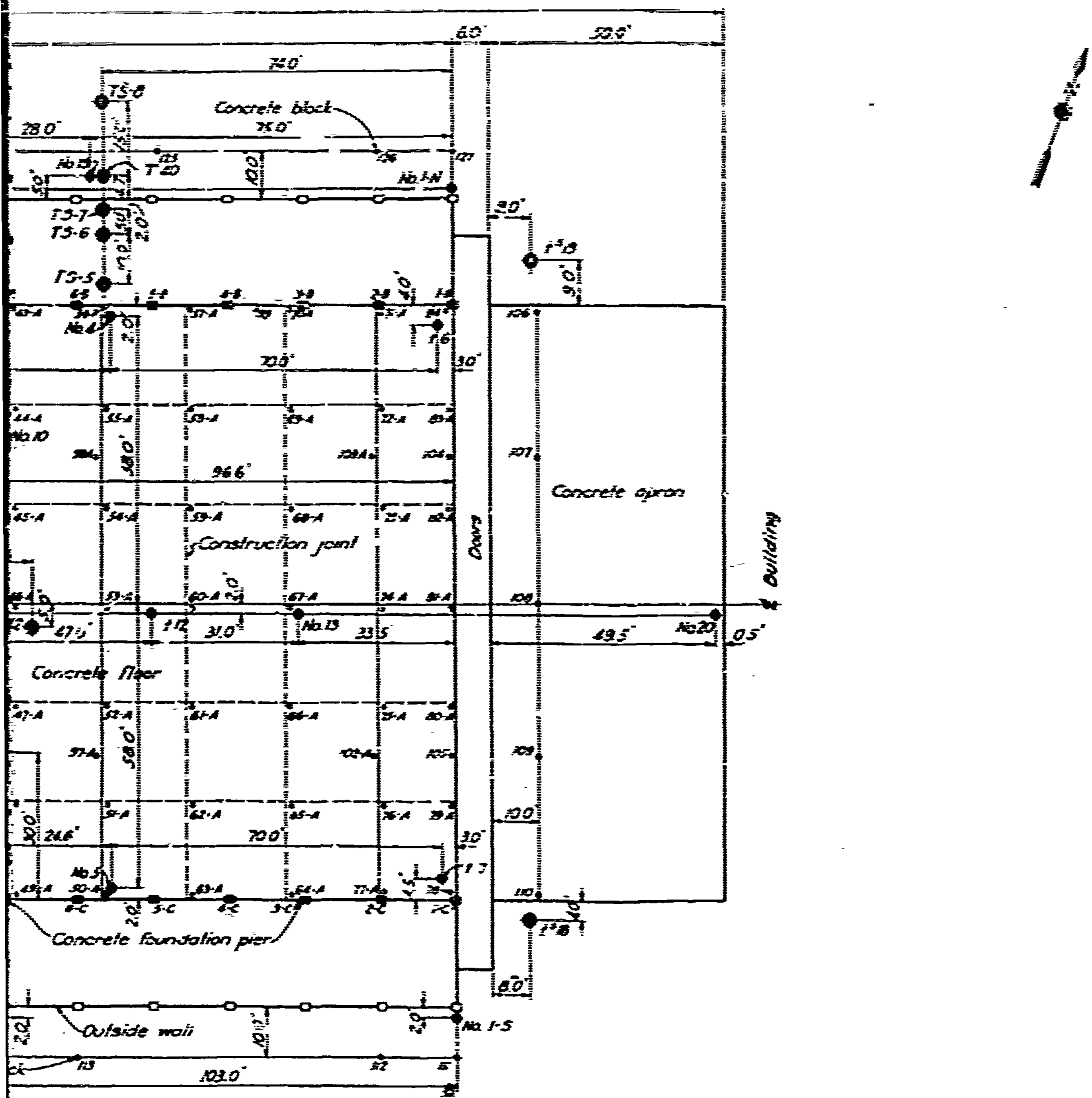
CORPS OF ENGINEERS, ST PAUL, MINN. MAY 1950

B

PLATE I-15



320.4'
30.0
6.0'
11.0'
94.6'
28.0'
No.3-N
Outside wall
No.2-N
TS-8
T 40
TS-7
TS-6
TS-5
Boiler Room
101.0'
No.14
No.15
No.18
No.1
No.10
71.0'
61.6'
37.0'
No.4
Concrete apron
Expansion joint
Doors
No.22
49.5'
33.5'
No.8
33.0'
30.0'
No.3
47.6'
Concrete floor
No.11
10.0'
35.0'
73.0'
24.6'
No.17
No.2
No.16
No.5
Concrete foundation
No.3-S
No.21
T 39
No.2-S
Outside wall
74.0'
105.6'
Concrete block
Building
70.5'
78.0'
162.63'
147.63'
120.12'
LEGEND
TS-Supplementary thermoc
Ground temperature obs
Frost level observation p
Vertical movement obser
T-Thermocouple units.
t-Single thermometer.
t^s-Thermometer strings



LEGEND

Supplementary thermocouple units.
Ground temperature observation hole.
Frost level observation point.
Vertical movement observation point.
Thermocouple units
Single thermometer.
Thermometer strings

B

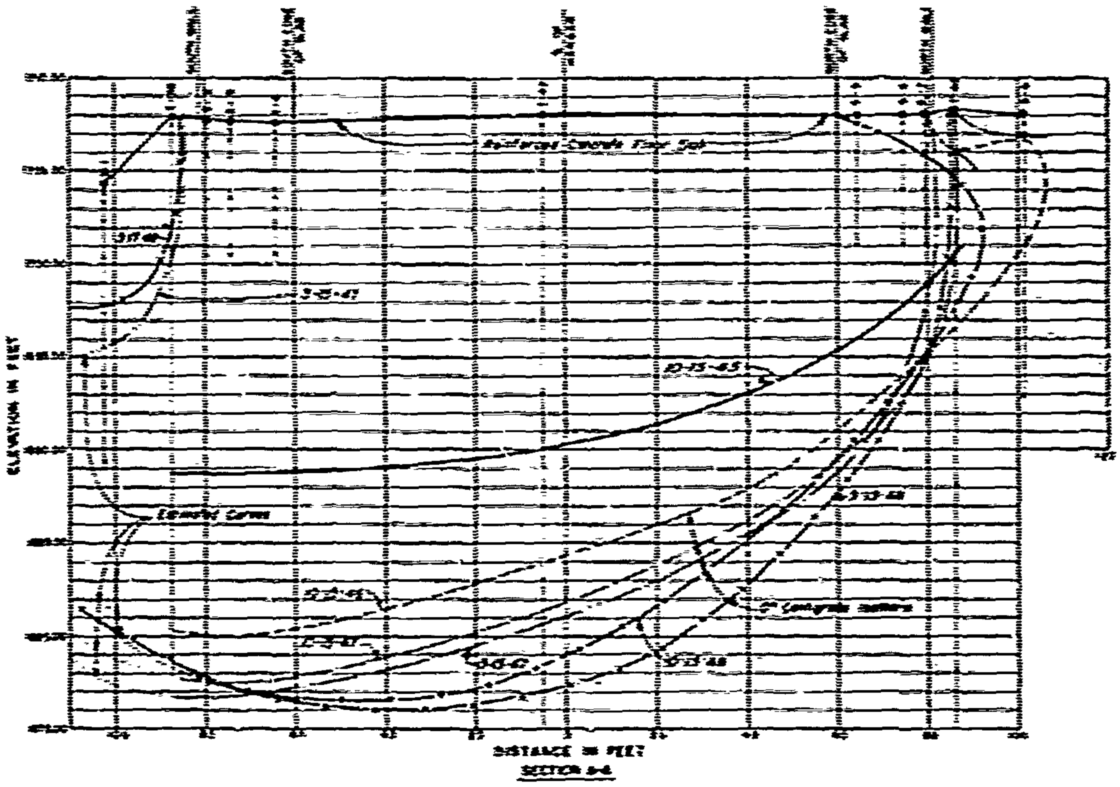
PERMAFROST INVESTIGATION
NORTHWAY AIRFIELD, ALASKA
OBSERVATION POINTS IN HANGAR

IN 1 SHEET — SCALE IN FEET — SHEET NO. 1

U.S. ENGINEER OFFICE, ST. PAUL, MINN. MAY 19[illegible]

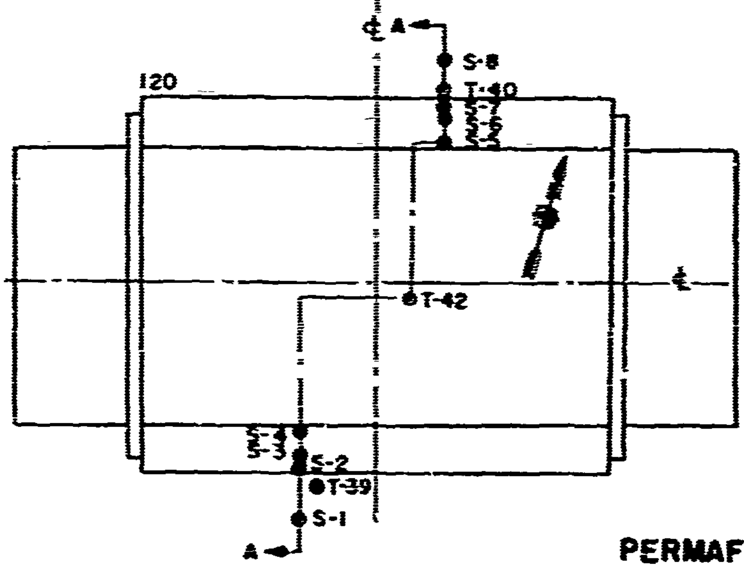
DRAWN BY: A.M.J.
TRACED BY: G.F.
CHECKED BY: A.M.J.

PLATE I-16



LEGEND

- SURFACE THERMOCOUPLE
- SUBSURFACE THERMOCOUPLE



LOCATION PLAN

80 0 80

SCALE IN FEET

PERMAFROST INVESTIGATION

NORTHWAY AIRFIELD, ALASKA

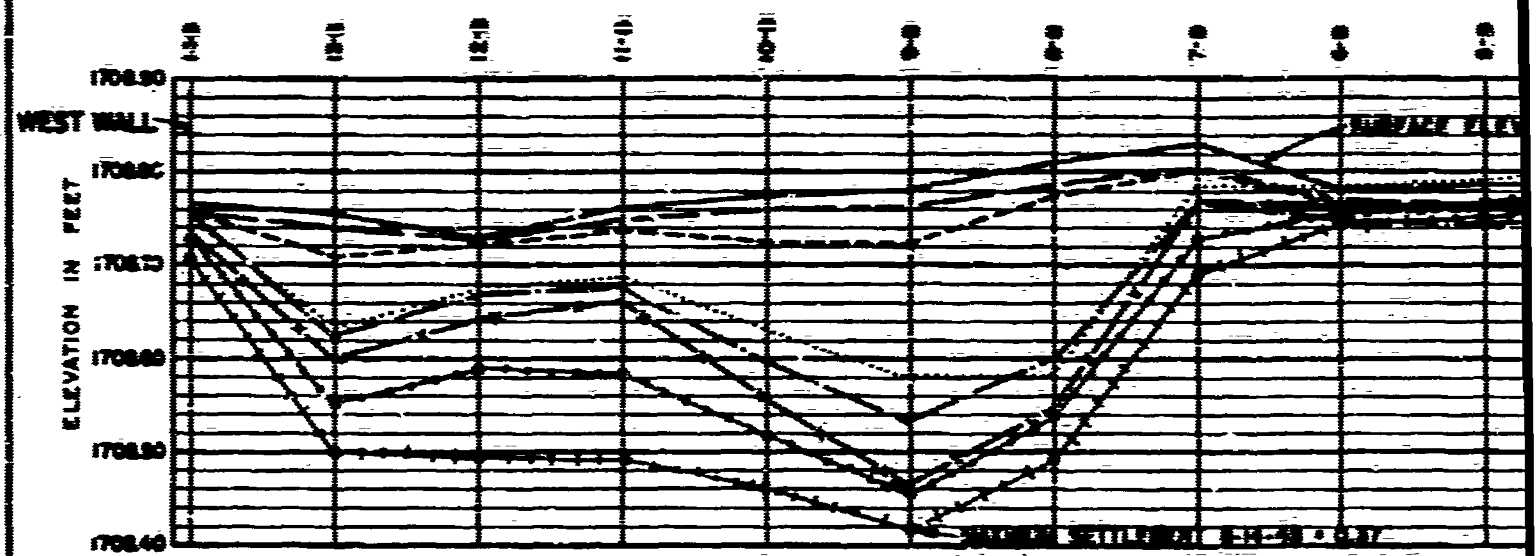
HANGAR

COMPARISON OF 0° C. ISOTHERMS

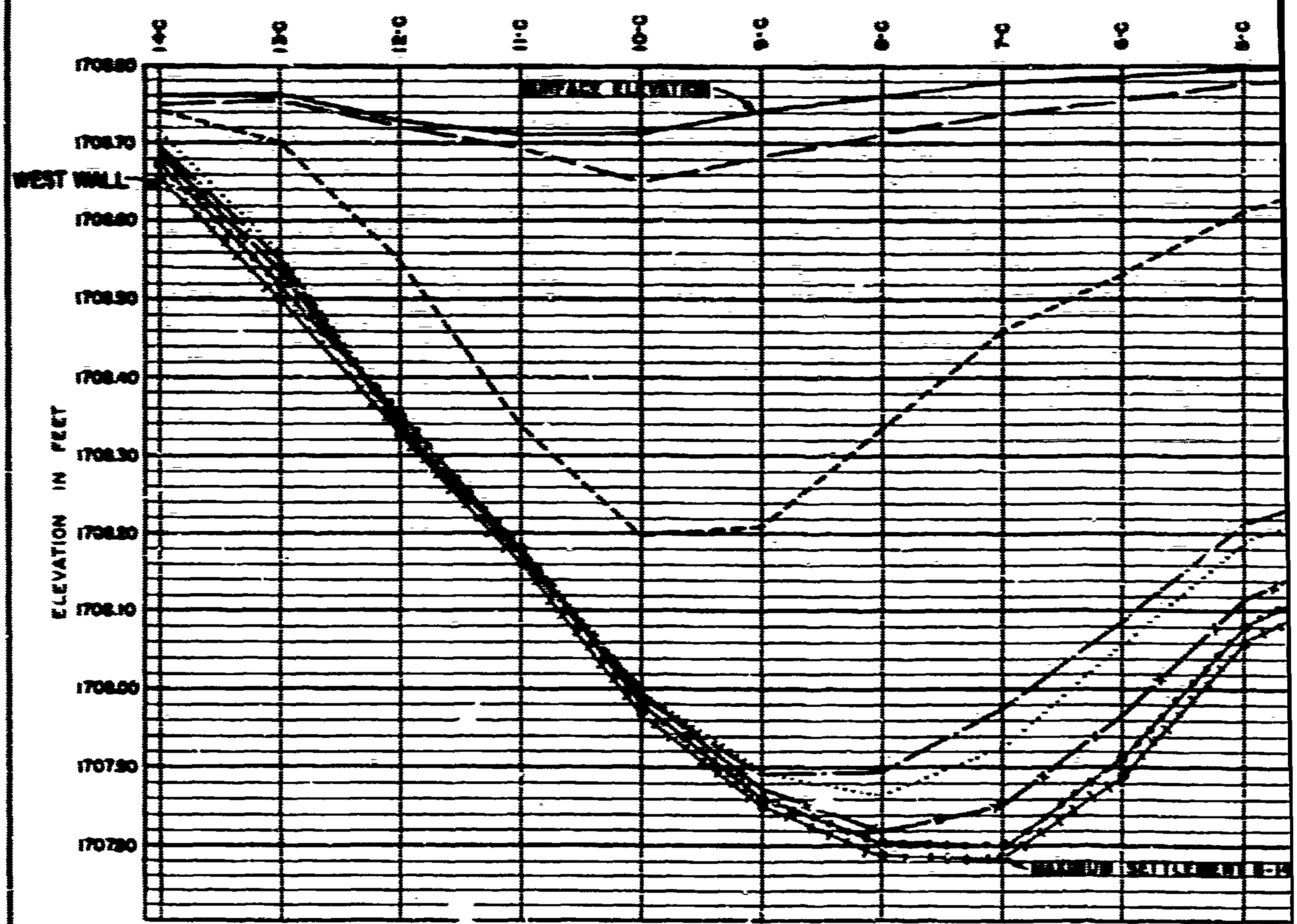
SCALE AS SHOWN

CORPS OF ENGINEERS, ST. PAUL, MINN. MAY, 1950

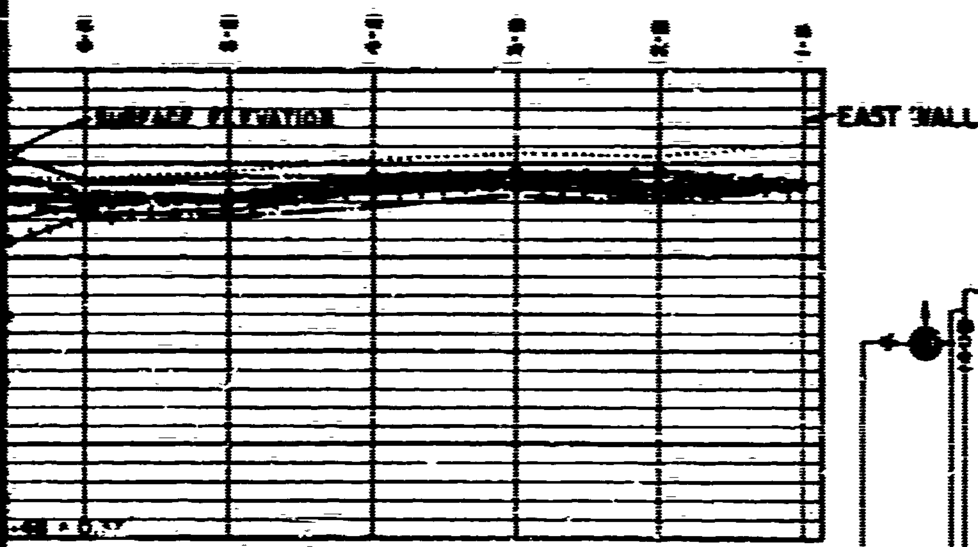
PLATE I-17



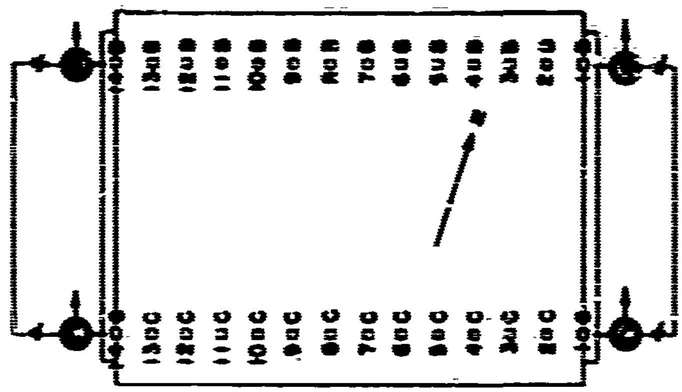
SECTION B-B NORTH WALL CONCRETE FOUNDATION PI



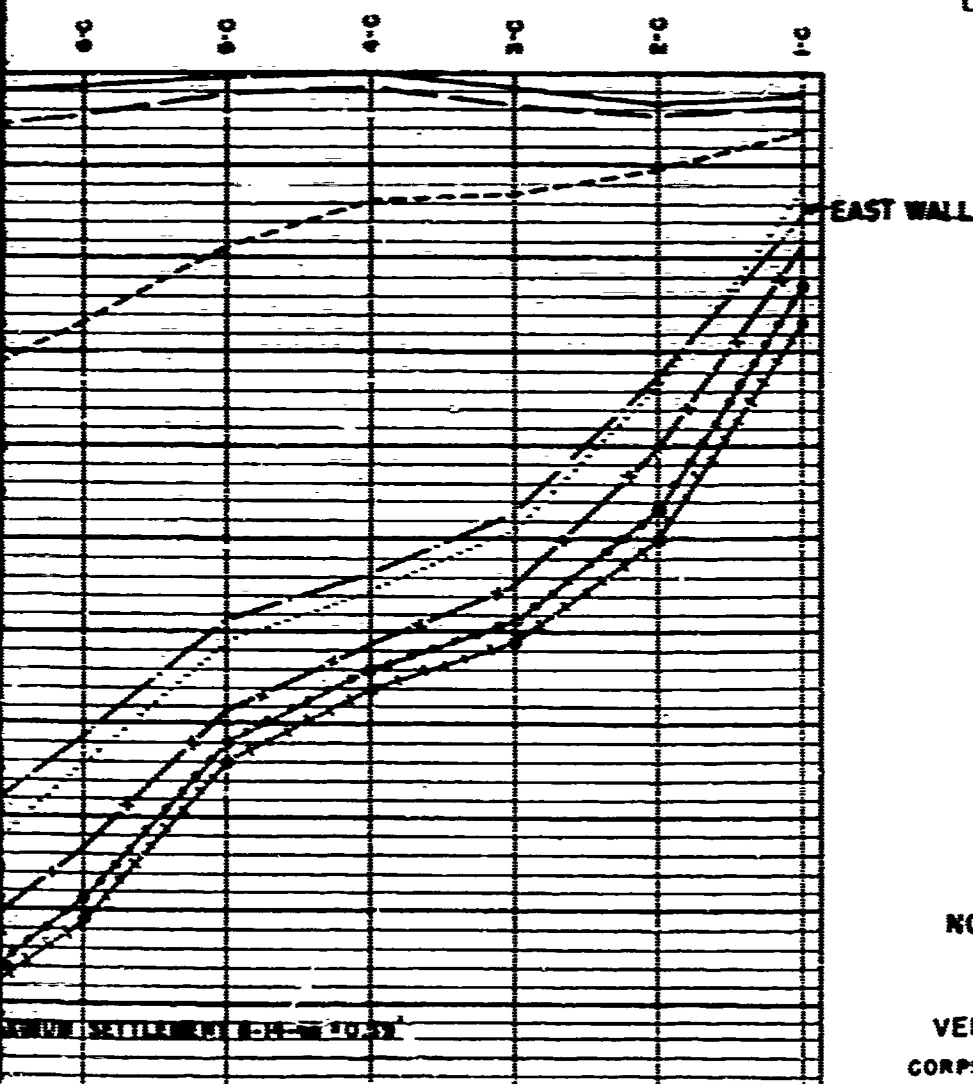
SECTION C-C SOUTH WALL CONCRETE FOUNDATION PIE



E FOUNDATION PIERS



LOCATION PLAN



E FOUNDATION PIERS

LEGEND

3-31-45
7-2-45
3-7-46
11-20-46
3-6-47
11-5-47
4-30-48
8-14-48

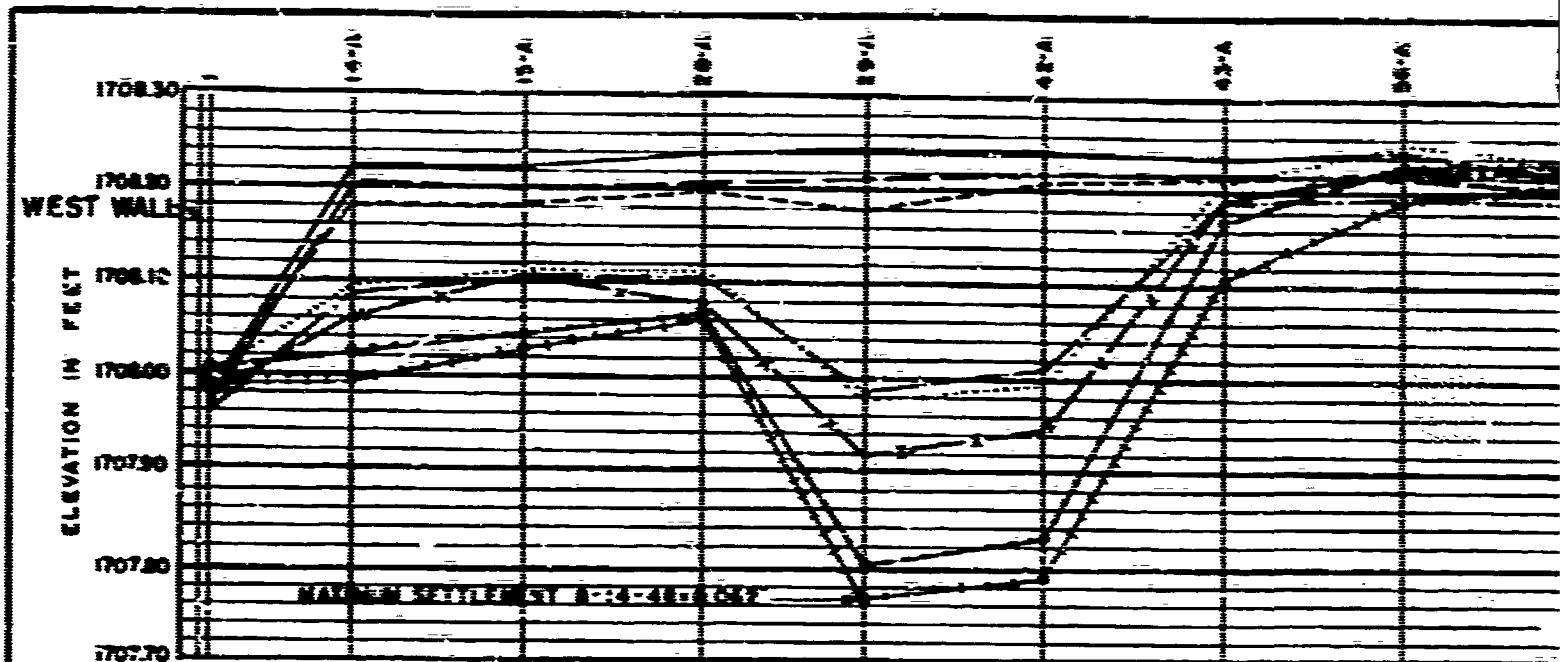
VERT. 0.2 0 0.2
HORIZ. 20 0 20
SCALE IN FEET

PERMAFROST INVESTIGATION
NORTHWAY AIRFIELD, ALASKA
HANGAR
CONCRETE FOUNDATION PIER
VERTICAL MOVEMENT OBSERVATIONS

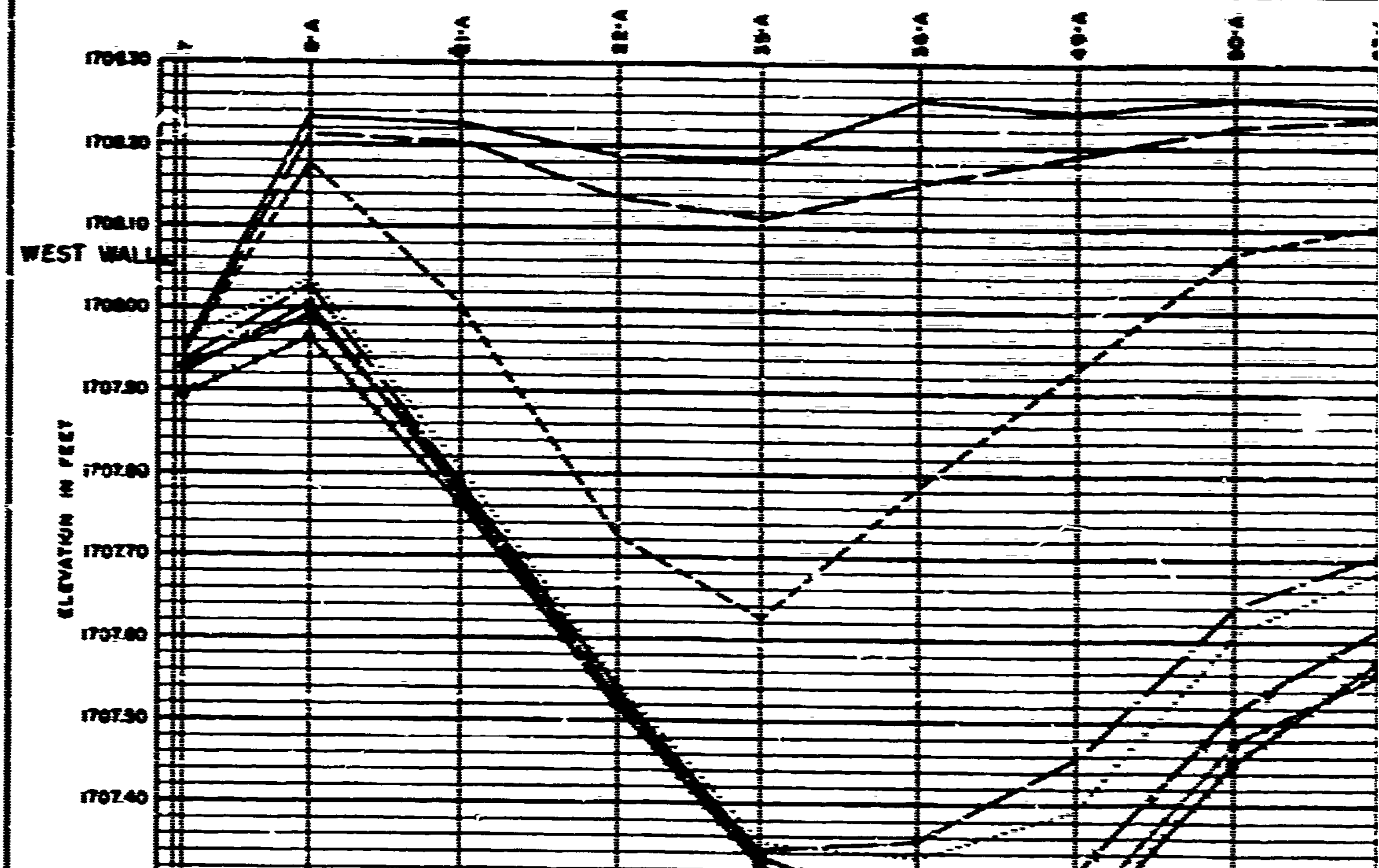
CORPS OF ENGINEERS, ST PAUL, MINN. MAY 1950

B

PLATE I-18

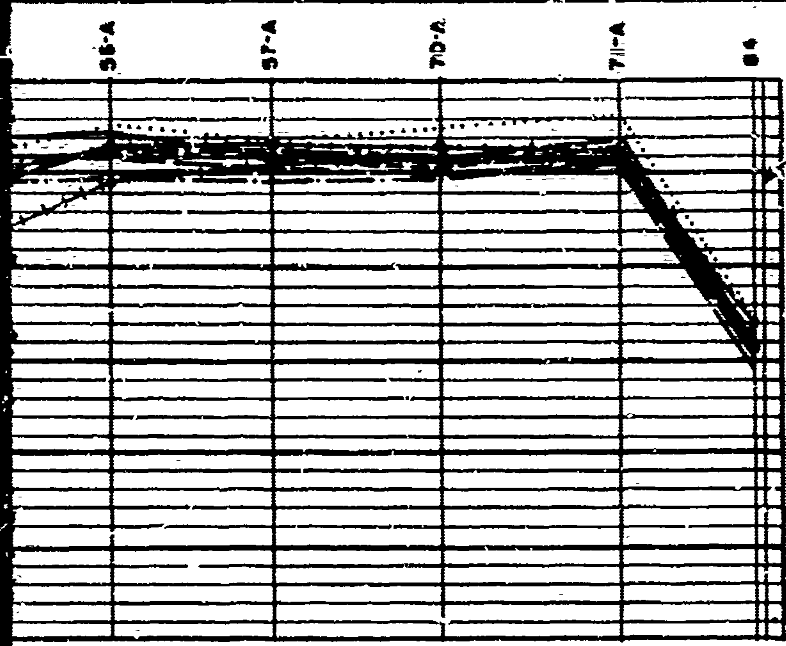


SECTION A-A CONCRETE FLOOR SLAB POINTS ADJACENT TO NO

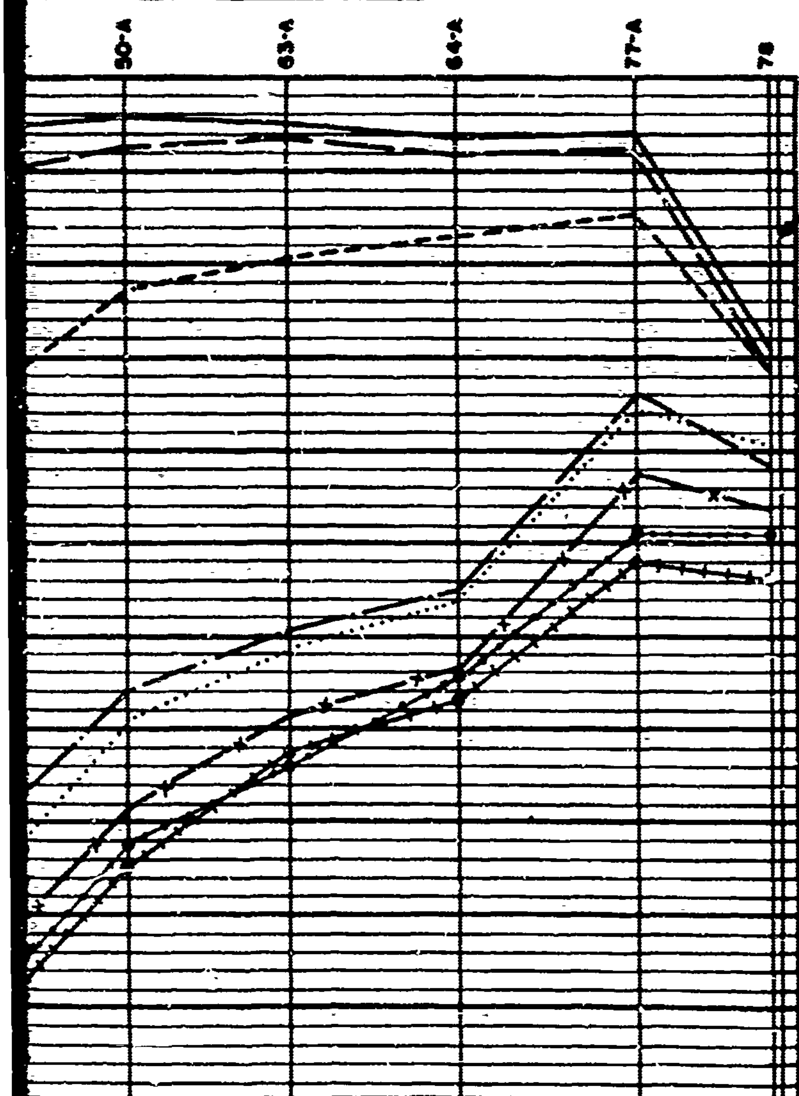


A

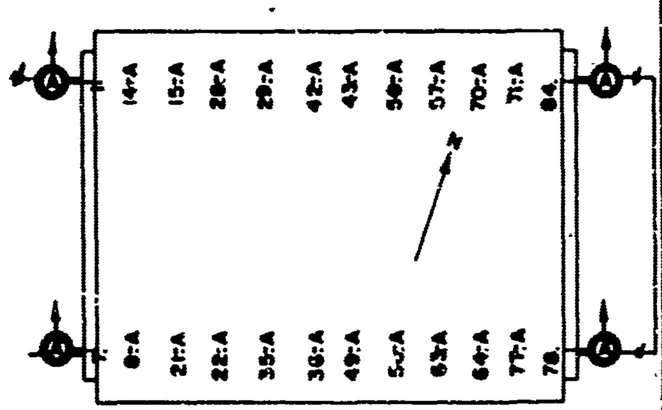
SECTION A'-A' CONCRETE FLOOR SLAB POINTS ADJACENT TO SOU



DJACENT TO NORTH WALL



DJACENT TO SOUTH WALL



LOCATION PLAN

80 0 80
SCALE IN FEET

LEGEND

3-31-45	———
7-2-45	—— ——
3-7-46	- - - - -
11-20-46	—·—·—
3-6-47	···········
11-5-47	x———x
4-30-48	o-------o
8-14-48	o+++++o

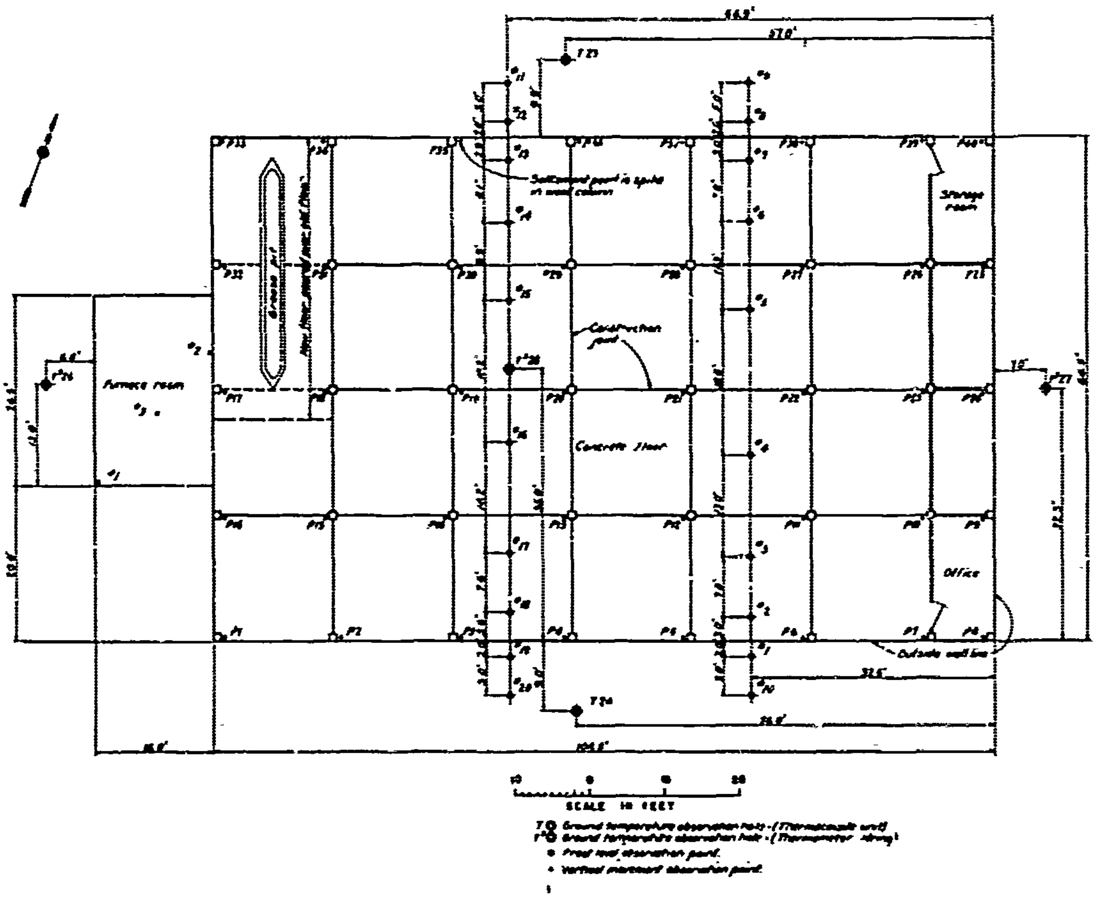
VERT. 0.2 0 0.2
HORIZ. 20 0 20
SCALE IN FEET

PERMAFROST INVESTIGATION
NORTHWAY AIRFIELD, ALASKA
HANGAR
CONCRETE FLOOR SLAB
VERTICAL MOVEMENT OBSERVATIONS

CORPS OF ENGINEERS, ST. PAUL, MINN. MAY 1950

B

PLATE I-19



THIS DRAWING SHOWS LOCATION OF OBSERVATION POINTS SUBSEQUENT TO JULY 23, 1946.

PERMAFROST INVESTIGATION
NORTHWAY AIRFIELD, ALASKA
OBSERVATION POINTS IN MOTORPOOL BLDG.

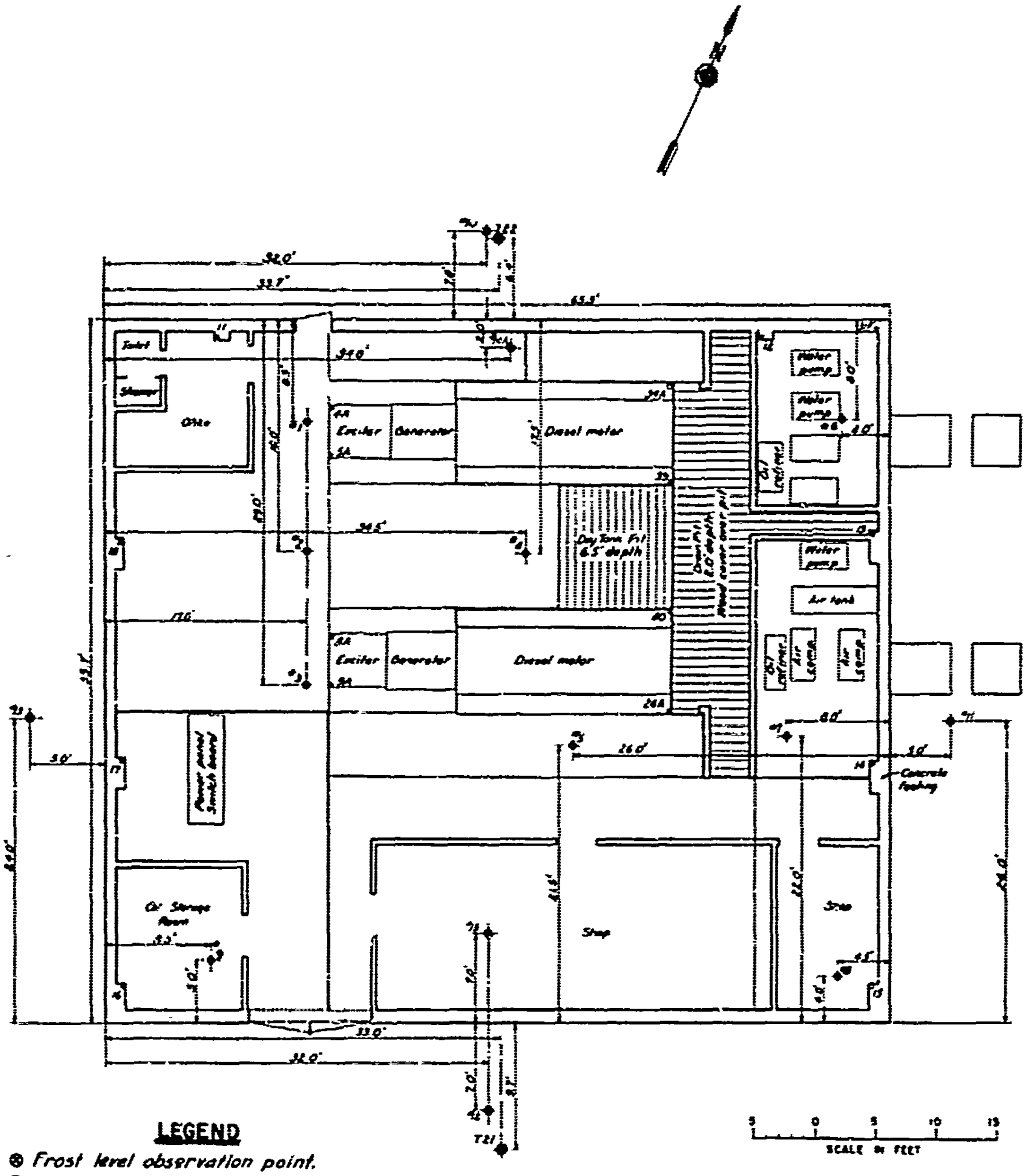
IN 1 SHEET | SHEET NO 1

U.S. ENGINEER OFFICE, ST. PAUL, MINN. MAY 1950

DRAWN BY: J.M.J.
TRACED BY: J.M.J.
CHECKED BY: V.a.K.

PLATE I - 20

KI - R - 10/64



LEGEND

⊗ *Frost level observation point.*

21 ◎ *Ground temperature observation hole:(Thermocouple unit)*

∘ *Vertical movement observation point.*

THIS DRAWING SHOWS LOCATION OF OBSERVATION POINTS SUBSEQUENT TO JULY 23, 1946.

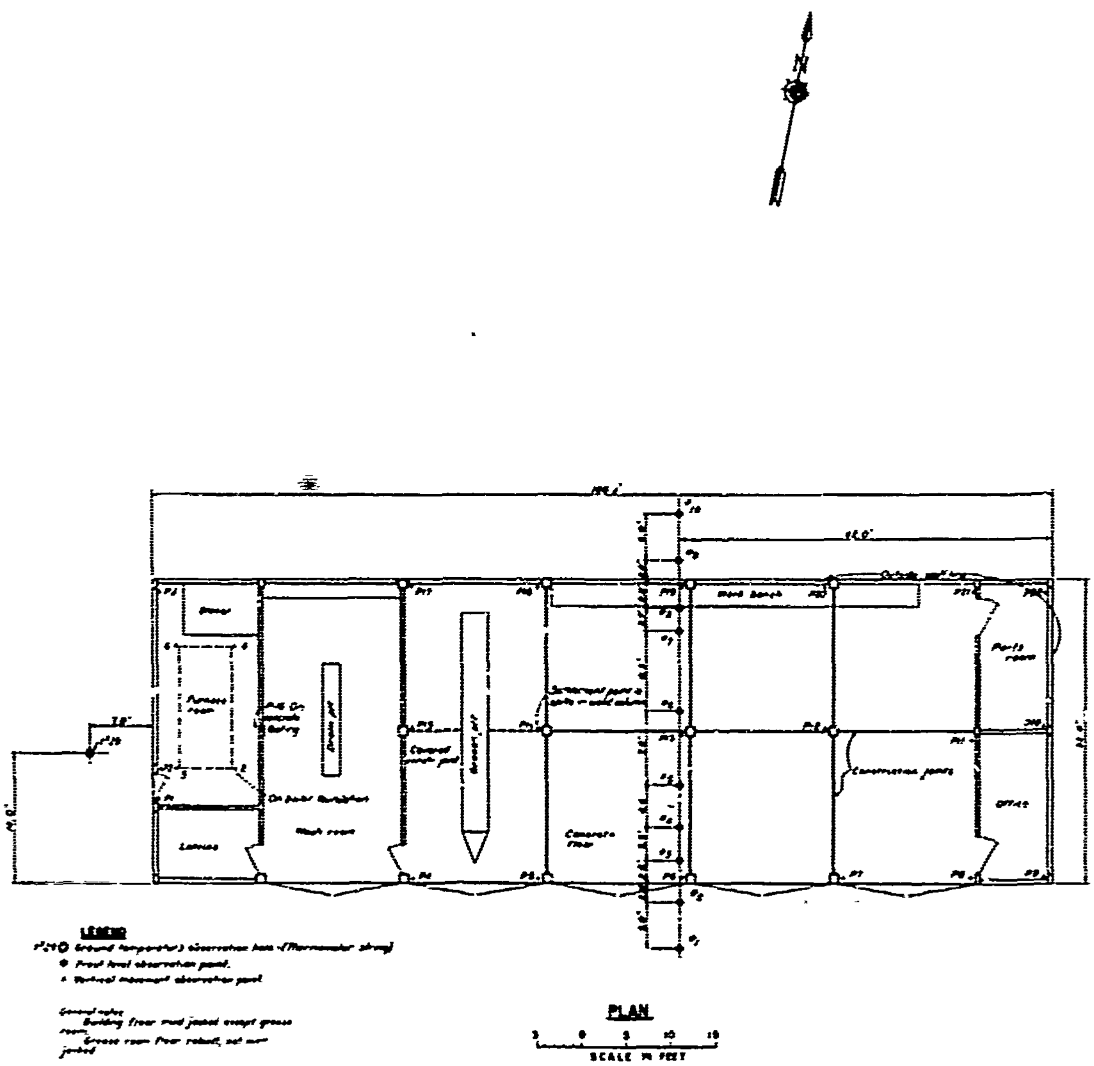
PERMAFROST INVESTIGATION
NORTHWAY AIRFIELD, ALASKA
OBSERVATION POINTS IN POWER HOUSE

IN 1 SHEET — SHEET NO 1

U S ENGINEER OFFICE, ST PAUL, MINN. — MAY 1950

DRAWN BY: L.H.S.
TRACED BY: E.C.A.
CHECKED BY: J.M.J.

PLATE I-21



THIS DRAWING SHOWS LOCATION OF OBSERVATION POINTS SUBSEQUENT TO JULY 23, 1946.

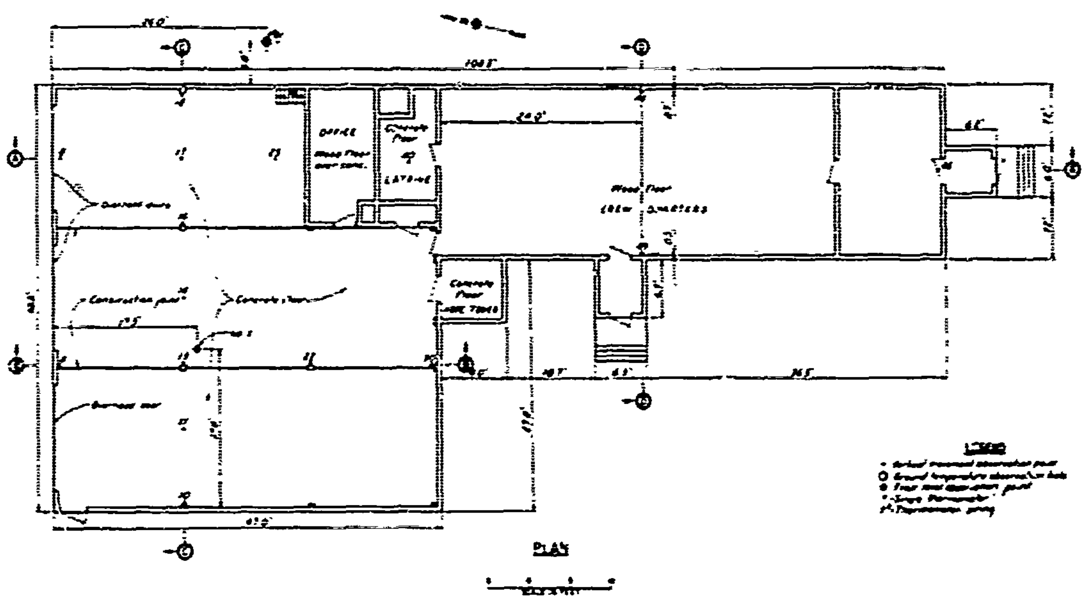
PERMAFROST INVESTIGATION
NORTHWAY AIRFIELD, ALASKA
OBSERVATION POINTS IN AND ADJACENT TO GARAGE

IN 1 SHEET — SHEET NO. 1

U.S. ENGINEER OFFICE, ST. PAUL, MINN. — MAY 1950

DRAWN BY: J.M.J.
TRACED BY: A.W.L.
CHECKED BY: J.M.J.

PLATE I-22



PERMAFROST INVESTIGATION

NORTHWAY AIRFIELD, ALASKA

OBSERVATION POINTS IN FIRE STATION

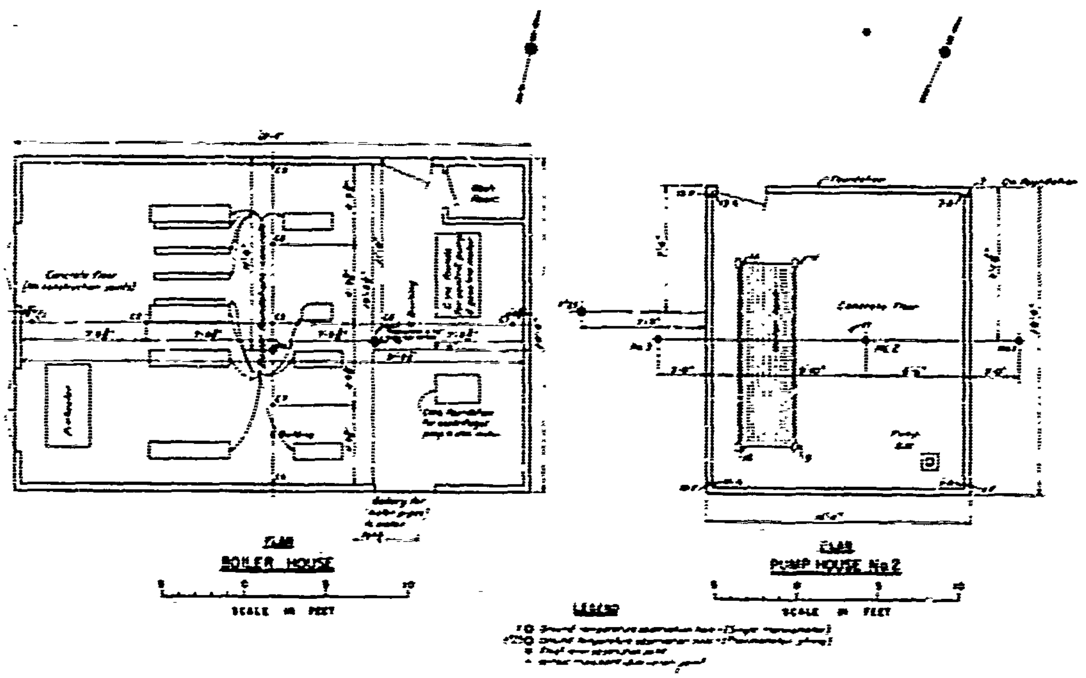
IN 1 SHEET SHEET NO. 1

5 0 5 10
SCALE IN FEET

U.S. ENGINEER OFFICE, ST. PAUL, MINN. MAY 1950
SUBMITTED

DRAWN BY. P.F.S
TRACED BY. O.P.A
CHECKED BY. K.G.H

PLATE I-23



THIS DRAWING SHOWS LOCATION OF OBSERVATION POINTS SUBSEQUENT TO JULY 23, 1946.

PERMAFROST INVESTIGATION
NORTHWAY AIRFIELD, ALASKA
OBSERVATION POINTS IN BOILER HOUSE & PUMP HOUSE

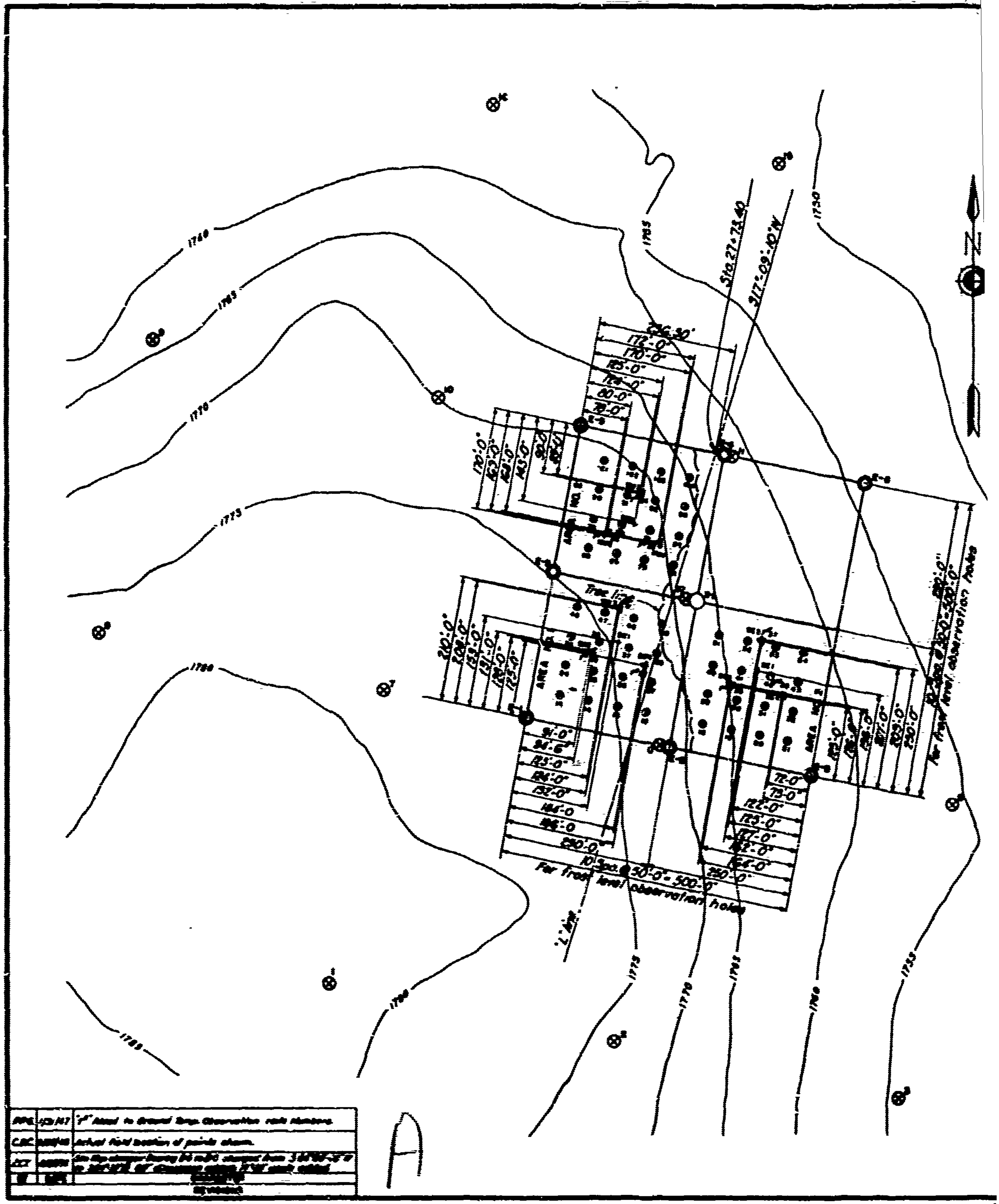
IN 1 SHEET SHEET NO. 1

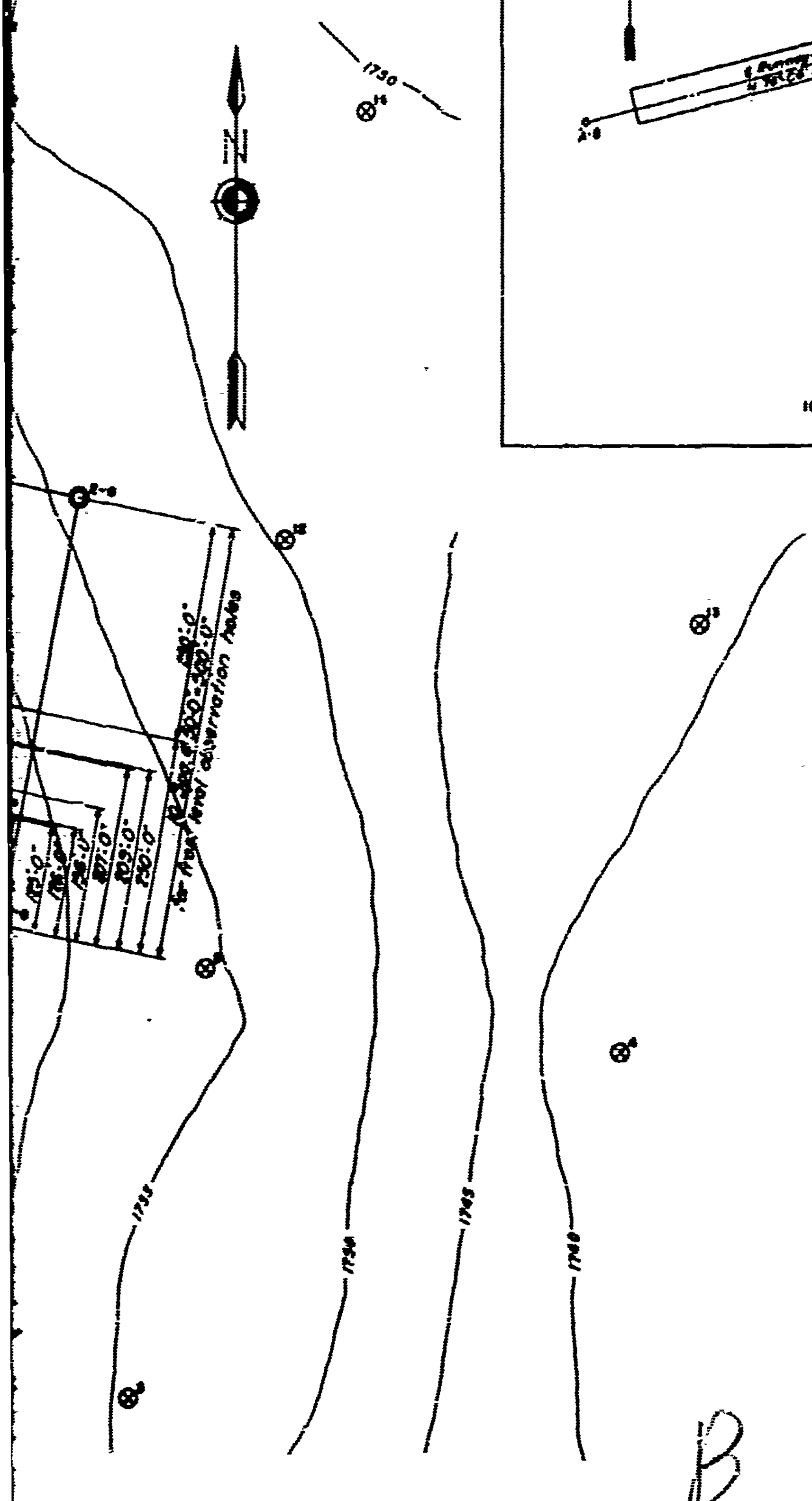
SCALE: AS SHOWN

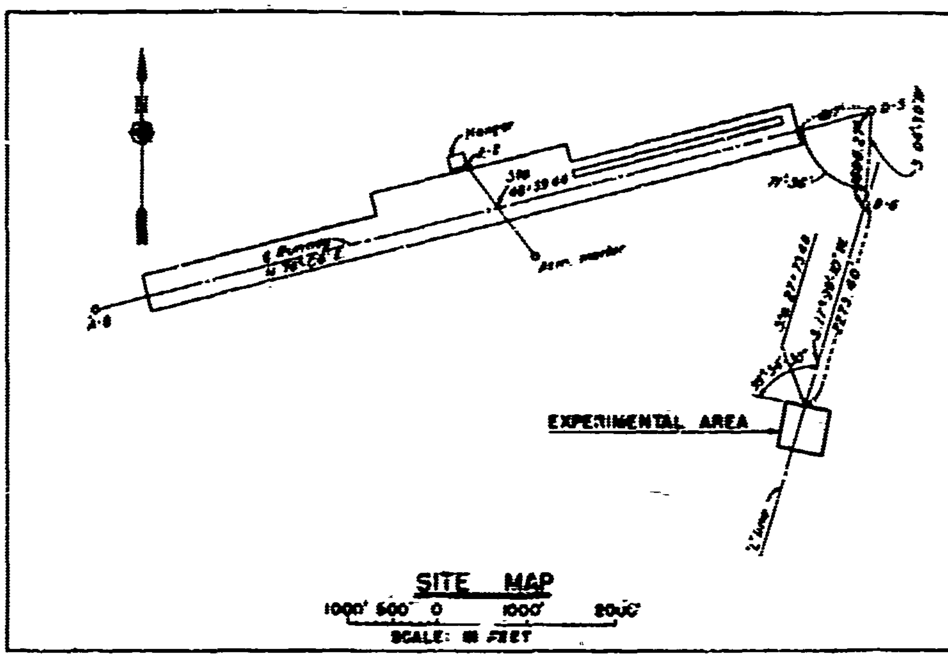
U.S. ENGINEER OFFICE, ST. PAUL, MINN. MAY 1950

DRAWN BY: J.M.J.
TRACED BY: A.M.L.
CHECKED BY: J.M.J.

PLATE I-24


Tree line
For frost level observation holes
10 Spa. @ 50'-0" = 500'-0"
For frost level observation holes
'L' line
Actual field location of points shown.
REVISIONS





THIS DRAWING HAS BEEN REDUCED
TO ONE-HALF THE ORIGINAL SCALE

LEGEND

- ⊗ Ground water observation hole
- • Frost level observation hole
- Exploratory boring - churn drill
- ○ Exploratory boring - core drill
- Ground temperature observation hole
- \+ Vertical movement observation point
- Thermometer strings

Area No 1 - Moss & peat.
Area No 2 - Stripped of vegetation
Area No 3 Natural state.

PERMAFROST INVESTIGATION
NORTHWAY AIRFIELD, ALASKA
OBSERVATION POINTS IN EXPERIMENTAL AREA

IN 1 SHEET — SHEET NO. 1

100' 50' 0 100' 200'
SCALE: IN FEET

U.S. ENGINEER OFFICE, ST. PAUL, MINN. — MAY [illegible]

DRAWN BY: [illegible]
TRACED BY: A.J.S.
CHECKED BY: [illegible]

PLATE 1-25